

SURGERY OF CHILDHOOD.

BY

JOHN FRASER

MC MD ChM FRCSE

REGIUS PROFESSOR OF CLINICAL SURGERY IN THE UNIVERSITY
OF EDINBURGH CONSULTING SURGEON TO THE ROYAL
HOSPITAL FOR SICK CHILDREN EDINBURGH

IN TWO VOLUMES

Vol II

ILLUSTRATED

LONDON

EDWARD ARNOLD & CO

1926

[All rights reserved]

Made and Printed in Great Britain by
Butler & Tanner Ltd., Frome and London

CONTENTS OF VOL II

CHAP	PAGE
XXIX SURGERY OF THE NECK	609
XXX DISEASES OF THE CHEST	671
XXXI DISEASES OF THE SPINE	690
XXXII HERNIA AND UNDESCENDED TESTIS	740
XXXIII SURGERY OF THE ABDOMEN	701
XXXIV DISEASES OF THE RECTUM AND ANUS	860
XXXV SURGERY OF THE GENITO URINARY SYSTEM	884
XXXVI SURGERY OF THE GENITO URINARY SYSTEM (<i>continued</i>)	926
XXXVII THE SURGICAL CONSIDERATIONS OF THE PARALYSES OF CHILDHOOD	948
XXXVIII THE SURGERY OF THE UPPER EXTREMITY	985
XXXIX SURGICAL DISEASES OF THE LOWER EXTREMITY	1013
APPENDIX—METHOD OF MAKING CELLULOID SPLINTS	1109
INDEX	1113

SURGERY OF CHILDHOOD

CHAPTER XXIX

SURGERY OF THE NECK

CERVICAL DEVELOPMENTAL ERRORS OF SURGICAL SIGNIFICANCE

There are certain errors of developmental origin in the neck which are of surgical importance in so far as they are amenable to operative treatment. These errors are as follows —

Branchial fistule

Branchial fibro chondromata

Branchial cysts

Dermoid cysts

THE SURGICAL ANATOMY OF THE DEVELOPMENT OF THE NECK

The wall of the primitive pharynx of the embryo is formed by a series of superimposed tissue divisions, known as the visceral or branchial arches. Four such arches, each bounded caudally by a depression, may be recognized on each side of the pharynx of a four weeks old embryo. Fifth and sixth arches exist, but they are not superficially differentiated from the body wall. The inner aspect of the arches is covered with hypoblast, and the outer aspect with epiblast, between each arch there is a recess in which hypoblast and epiblast come in contact, and the fusion is known as the cleft membrane. On the outer side of the membrane there is the 'external cleft depression,' on the inner side the 'internal cleft recess.' The second arch grows over and buries the third and fourth arches, and by so doing it encloses an epiblastic space of considerable size—the cervical sinus of His. It is an inclusion or a persistence of epiblastic formation which is responsible for the development of the various congenital malformations of the neck.

It is possible to delimit on the neck of the fully developed individual the position which the various cleft depressions originally occupied, and the knowledge is of importance in the recognition of the associated clinical conditions.

The position of the first cleft depression is outlined as extending from the external auditory meatus to a point immediately above the hyoid bone, the second corresponds to a line drawn from the anterior border of the sterno mastoid muscle immediately below the lobule of the ear to the body of the hyoid bone. The lines of the third and fourth clefts cannot be separately differentiated, but conjointly they

correspond to a line which extends from the middle of the posterior edge of the sterno-mastoid to a point about 1 inch above the supra-sternal notch.

Branchial Fistulæ

Primary and secondary varieties of branchial fistulæ are recognized. A *primary fistula* results from an imperfect obliteration of one of the branchial clefts (external cleft depression), and as such it exists at birth, while a *secondary fistula* develops as the result of the spontaneous or the artificial opening of a branchial cyst. A distinction is some-

times drawn between lateral and median fistulæ, but median fistulæ are not of branchial origin: they are developmental errors which arise in connection with the persistence of the thyro-glossal duct, and their etiology and clinical features are separately described.

CLINICAL FEATURES. The true branchial fistulæ are usually unilateral; occasionally they are bilateral and symmetrical. Their origin is easily understood if the scheme of development of the neck is appreciated. The external cleft-depression is obliterated by a fusion of the opposing edges, and if the fusion is incomplete an epithelial-lined orifice persists, which leads into an epithelial-lined tract of varying depth and length. The ex-



FIG. 333.—Branchial Fistula (Boy 4½ years).

The fistulous tract opens at the lower end of the anterior border of the right sterno-mastoid muscle. Two strands of silkworm gut have been passed into the sinus.

ternal orifice is often indicated by a nodule of skin; in some cases it is represented by an opening which is so small that it barely admits a fine probe. The fistulæ are situated at the anterior border of the sterno-mastoid muscle; more exactly, the positions in which they are found are opposite the angle of the jaw, opposite the thyro-hyoid space, or immediately above the sterno-clavicular articulation. In a certain proportion of cases, there is an internal orifice and, irrespective of the position of the external opening, it is situated in the region of the sinus pyriformis or of the tonsil. If both internal and external orifices exist with an intermediate and communicating tract, the sinus is said to be *complete*, while an *incomplete*

sinus is one in which only an external or an internal orifice exists. The course of the tract which underlies the fistula has a constant relationship to the surrounding parts. From the external orifice it follows the line of the anterior border of the sterno mastoid muscle to the level of the greater cornu of the hyoid bone, it then dips to a deeper level, to pass beneath the posterior belly of the digastric muscle, and between the internal and external carotid vessels, and from this point it extends inwards to the lateral wall of the pharynx.

On the surface of the neck, the orifice of the fistula may be recognized as a minute circular opening, through which, from time to time, a clear fluid exudes, and during the periods of active secretion the output is increased by mastication and ingestion. Downward pressure on the neck may produce an escape of the fluid. An incomplete internal fistula may remain unrecognized, but when its presence is suspected, pressure on the side of the neck may result in an escape of fluid into the mouth. In a complete fistula the course of the tract may be demonstrated by the injection of a bismuth emulsion into the external orifice and subsequent X ray examination.

If judged by the actual size of the orifice it would seem as though the condition were of little clinical importance, but developments may arise which give the condition considerable significance. The persistence of superficial discharge may be annoying, fluid may collect in the deeper portions of the tract (cystic fistulæ), and, when it does this an irritating cough may develop—that this is the result of a reflex irritation can be demonstrated, because the introduction of a probe into the tract or the injection of fluid under tension gives rise to a cough and painful pharyngeal irritation—but perhaps the fact of greatest clinical significance is the liability to malignant change which appears in later life.

DIAGNOSIS The difficulty of actual recognition of the fistula is the first point in diagnosis. When it is discovered, it may be mistaken for a sinus communicating with an infected gland, but the history, the absence of inflammatory reaction in the surroundings, and the appearance of the escaping fluid are characteristic of the congenital error.

TREATMENT Total extirpation of the fistula and its associated tract is the only efficacious treatment. If the fistula is an incomplete external one, and if it is especially desirable to avoid a scar, the injection of a few drops of tincture of iodine into the orifice may produce an inflammatory reaction which results in obliteration of both tract and fistula, but conditions are rarely favourable for such treatment.

If operation is chosen, it is essential that the extirpation shall be a complete one, and as the tract is in close relationship to a number of important structures, the operation is one of considerable difficulty and of a certain amount of danger. A large incision is necessary, the visceral surface of the tract is dissected free, and that portion which communicates with the pharynx is removed by invaginating the terminal portion into the interior of the mouth by means of a

probe and then excising it. To leave any portion of the epithelial tract behind is to risk the appearance of a swelling and the persistence of discharge from the wound.

Branchial Cysts

If a portion of the branchial cleft (external cleft depression) remains unobliterated among the tissues of the neck, and if this remnant has no existing communication with the surface, it may form the nucleus from which a branchial cyst develops. Owing to the comparatively large extent of the cervical sinus, it is in this situation that the cysts most commonly form.

THE METHOD OF FORMATION. A branchial cyst contains clear



FIG. 334.—Branchial Cyst (Boy 3½ years).

The cystic tumour is apparent at the lower end of the sterno-mastoid muscle.

fluid, and, in distinction to a dermoid cyst, there is no proliferation of the lining epithelium. It would therefore seem likely that the epithelium possesses a secretory function, and it is the gradual accumulation of the fluid within the confines of the space which gives rise to the development of the cyst.

PATHOLOGY. The cyst wall is formed of dense fibrous tissue, its outer surface is rough, and it is adherent to the surrounding parts; in contrast to this, the interior is smooth and glistening, and of a greenish-yellow colour; microscopical examination shows that it is lined with cubical-shaped epithelium.

The fluid in the interior is clear, sometimes watery in consistency, sometimes gelatinous or mucus-like, and, as hæmorrhages into the wall of the cyst are of frequent occurrence, it is often of a brownish colour from the presence of effused blood.

CLINICAL FEATURES. It is unusual for cysts to be evident at birth; they generally become apparent about puberty. They grow slowly, with occasional sudden increases in size, which probably are coincident with the occurrence of hæmorrhages into the cyst cavity, and their development is symptomless until they become of such a size that pressure symptoms are produced. Their position in the neck is below the level of the hyoid bone and at the anterior border of the sterno-mastoid muscle. The swelling is an elongated one, smooth in outline, movable transversely, but somewhat fixed

in the vertical plane. Owing to the dense structure of the fibrous wall and the tension of the fluid it contains, the tumour has such a hard consistency that it may be mistaken for a solid tumour. The overlying skin is not adherent to the cyst wall. Branchial cysts are liable to periodic attacks of inflammation, these developments are associated with an increase in the bulk of the tumour, and subsequent to this the contents may become purulent in character. In the latter event, a subcutaneous abscess develops, which, bursting on the surface, establishes a persistent sinus.

DIAGNOSIS Branchial cysts may be mistaken for solid tumours arising from lymphatic glands, but the subhyoid position, the uniform outline of a solitary swelling, and the fixation in the vertical axis are characteristic of the branchial cyst. Cystic hygromas are distinguishable by their appearance at an early age, by the large extent of the swelling, by the multilocular outline, and by the translucency of the cyst wall.

TREATMENT Complete extirpation is the only treatment which will prevent recurrence. If the cyst is not adherent to the surrounding tissue, its removal may be a simple matter, but adhesions may make the operation exceedingly difficult.

The operator must ascertain whether or not a branchial tract is present in addition to the cyst, and if such is found it must be dissected free and removed.

Branchial Fibro-chondromata

One of the constituents of each visceral arch is a skeletal basis of cartilage, each basis playing a part in the formation of the various osseous and cartilaginous structures of the neck. It occasionally happens that portions of the original formation become detached in the process of development, and, when such is the case, the remnant



FIG 335.—Branchial Cyst at the anterior edge of the lower end of the Sternal mastoid Muscle (Boy 4 years old)

The condition was originally bilateral

may form the centre from which the various facial and cervical fibro-chondromata are derived.

CLINICAL FEATURES. The tumours exist as small hard appendages, usually pedunculated and invariably covered by adherent skin. They are found along the lines in which cleft depressions originally existed, and they therefore occur around the external ear, along the line of the inter-maxillary cleft as represented by a line drawn from the external auditory meatus to the corner of the mouth, and on the lateral aspect of the neck in the situations in which branchial fistulae are found. The tumours are symptomless, but for æsthetic reasons they are, of course, objectionable. Montopen has recorded the tendency which exists for the tumour to be associated with congenital malformation of the mouth and ear.

PATHOLOGY. The tumours are not entirely composed of fibro-cartilage, many of them contain fat with bony and cartilaginous deposits in the interior, some are entirely composed of fibrous tissue. It is characteristic of the condition that the skin which covers the surface is always adherent to the deeper parts.

TREATMENT. It is obvious that removal of the tumour is the only available treatment. If it is pedunculated, it may be sufficient to divide the pedicle and to close the raw surface with a single suture, but sessile tumours demand the excision of a small area of skin around the base of the tumour.

Dermoid Cysts

It is difficult to distinguish closely between dermoid cysts and branchial cysts; both are due to inclusion of the epiblast, but the main basis of distinction is that, while the true branchial cyst contains clear or mucous-like fluid, the dermoid cyst contains cheese-like debris and desquamated epithelium. It has been suggested that the branchial cyst arises entirely from the branchial cleft recess, and that the epithelium of this region has peculiarities which account for the characteristic contents, while the dermoid cyst is reproduced from epiblast of a later stage of development in which sebaceous glands have appeared. The dermoid cysts which occur in the lateral aspects of the neck are examples of true or sequestration dermoids.

Lateral Dermoid Cysts. The majority of lateral dermoid cysts are found in the supra-hyoid region of the neck, and the position of the first branchial cleft is the most frequent site of their origin. They are therefore found behind the external ear, along the supra-mastoid crest, and in the region of the parotid. Sometimes they occupy a position which corresponds to that of the sub-maxillary-salivary gland, but it is unusual to meet with them below the level of the hyoid bone. They lie beneath the more superficial muscular aponeuroses; those which occur close to the skull are underneath the occipito-frontalis aponeurosis or even beneath the temporal muscle,

and, being thus in contact with the bone, they may indent its surface. The cervical varieties are beneath the platysma and the sterno mastoid muscle, and sometimes they lie deeper than the posterior belly of the digastric and the stylo hyoid muscles. In the last situation they may project into the floor of the mouth, and at times they adhere to the hyoid bone or to the styloid process.

When handled these swellings present all the characters of a cyst, but they are somewhat pasty in consistency, and they preserve the impression of the examining finger. If exposed by dissection, they are found to possess a sac wall of a yellowish wax leather appearance, adhesions to the surrounding parts are numerous, and the sac contains a pultaceous mass of sebaceous material and desquamated cells with such epiblastic evidences as hair and cuticle.

The higher dermoid cysts rarely attain a great size, because their



FIG 336 —Dermoid Cyst of right Supra clavicular Region (Boy $3\frac{1}{2}$ years)

bulk is limited by the compression of the surrounding aponeurosis, but the supra hyoid ones may attain a size so considerable as to interfere with both speech and swallowing.

DIAGNOSIS The various clinical characteristics of the tumour make it apparent that the cervical swelling is a cystic one, but it is difficult to carry the diagnosis farther than this. If the swelling is an 'impressionable' one, it means that it is a dermoid cyst, but it is exceptionable for this characteristic to be distinct. The situation of the swelling is of diagnostic importance, as supra mastoid and auricular cysts are usually dermoids, and when it is situated in the neck, the deeper it lies, the more likely it is to be dermoid in type, but the distinction between dermoid and branchial cysts must often remain doubtful until the swelling is actually exposed. It is unlikely that the large cystic hygromas of the neck will be confused with dermoids,

because of the comparatively large size and superficial position of the former.

TREATMENT. Exposure of the swelling and removal of it by careful dissection is the only available method of treatment. The liability which the tumour has of becoming fixed to the deeper structures of the neck makes the operation one of considerable difficulty, but a large incision and free exposure are the best guarantees of success.



FIG. 337.—Dermoid Cyst of left Supra-clavicular Region (Boy 6 years).

Lymphatic Cysts

(Hydrocele of the Neck, Congenital Cystic Hygroma)

Lymphatic cysts of considerable size may appear in the neck of an infant. It is most likely that they are congenital swellings in so far as they exist at birth, though their presence at this time may be unnoticed, but it is during the early months of life that they grow with rapidity and may assume a large size.

PATHOLOGY. Some doubt exists in regard to the exact manner of their origin. The swelling is actually a multilocular one, and the different cysts vary a great deal in size: some are as small as a pea, others are as large as a tangerine orange, and there is no doubt that, by the disappearance of inter-cystic partitions, a number of small

cysts become converted into a single large one

The cyst walls are so thin that they are translucent, and their arrangement is a delicate connective tissue lined by endothelial cells, the walls being so closely related to the surrounding tissue that it is often impossible to separate them without rupture. Clear serous like fluid which may coagulate on exposure to the air forms the contents of the cyst. The friability of the cyst wall increases the liability to hæmorrhage, and the fluid is often blood stained. The actual extent of the cystic



FIG. 338—Congenital Cervical Lymphangioma (Baby 4½ months)
Congenital cystic lymphangioma

formation varies within wide limits, frequently extending from the lower jaw to the clavicle, and it may even pass beneath the clavicle into the axilla. While the superficial limits of the swelling are uniform and distinct from the overlying skin, the deeper portions have a tendency to burrow and to infiltrate among the fibres of the muscles and the cellular planes of the neck, this peculiarity is important from the point of view of operative removal.



FIG. 339—Lymphangioma of Submaxillary Region (Boy 6½ years old)

While the pathology of the condition is thus easily appreciated, the explanation of the origin of the tumour is doubtful. Most likely it is an example of a rapidly growing type of lymphangioma. It is possible that the origin is to be found in isolated collections of lymphatic



FIG. 340.—Congenital Hygroma of Neck (Baby 6 weeks old).

There is a large cystic lymphangioma of the right cervical region

eases to spontaneous disappearance of the tumour. The cyst wall ruptures, and it is interesting to observe that when the contents are extravasated into the surrounding tissues, they are rapidly and completely absorbed. In this way a tumour of considerable size may disappear in the course of a few days, and its former presence is only recognizable by the looseness of the overlying skin.

SYMPTOMS. The cysts present a tumour of variable size. In outline they are round or lobulated, the overlying skin being of normal appearance and independent of the tumour, there is no pain. When the swelling is composed of a multiplicity of small cysts, the consistency is

tissue which have failed to establish communication with the general lymphatic system of the body, and which, being free from constructive influences, take on an erratic growth which accounts for their size and distribution. The fluid content is derived from the endothelial cells which line the interior of the cyst.

The Tendency to natural Cure. The rapidity with which the cysts tend to grow and the extreme delicacy of the cyst walls lead in many



FIG. 341.—Congenital Lymphangioma of Neck (Baby 3 months old).

Congenital hydrocele or hygroma of neck, affecting the sub-maxillary region

soft and flabby, but when a single large cyst is present, fluctuation can be made out. Beyond the deformity and the inconvenience of the swelling, there are no local symptoms, though in exceptional instances infiltration of the walls of the trachea and the pharynx may give rise to interference with respiration and deglutition.

DIAGNOSIS There is no other cystic tumour of the neck which presents characteristics similar to those of a cystic hygroma. Its congenital or early development, its rapid growth, sudden disappearance, and characteristic outline are distinctive features. A lipoma may simulate the condition, but is less localized, lacks fluctuation, and its interlobular connective tissue is attached to the deeper layers of the skin. A large angioma is sometimes confused with the hygroma, but examination should make the distinction easy.

Tuberculous lymphatic glands and branchial and dermoid cysts are excluded by the age at which their presence becomes apparent, and by their clinical characteristics.

TREATMENT While excision may be the ideal treatment, its adoption is advisable only in the small and circumscribed varieties of the disease. The larger the swelling the more likely it is to disappear spontaneously—we have seen a tumour of immense proportions disappear entirely within the space of forty-eight hours. Puncture is of little avail, because of the multilocular nature of the swelling, marsupialization has a similar objection. If excision is attempted, the operator must be prepared for an extensive dissection, because of the widespread deeper ramifications of the tumour. Neglect to observe complete removal is almost invariably followed by recurrence. In the majority of cases, the clinician is well advised to leave the condition alone in the practical certainty that when the swelling reaches a certain size it will disappear spontaneously.



FIG 342—Congenital Lymphangioma of Neck (Baby 4 months old)

The tension on the overlying skin is so great that sloughing has occurred

TORTICOLLIS OR WRYNECK

DEFINITION AND VARIETIES

A shortening of the sterno-mastoid muscle with its associated structures is spoken of as a torticollis or a wryneck. It is usual to recognize six varieties of the disorder based on etiology.

(1) *Congenital wryneck*, in which the error becomes apparent shortly after birth and progressively increases in degree.

(2) *Acute wryneck*, in which the muscle is the site of a primary or of a secondary infective involvement.

(3) *Traumatic wryneck*, in which injury to the muscle or its associated structures has resulted in the formation of fibrous tissue and subsequent shortening.

(4) *Spasmodic wryneck*, in which a nervous error is responsible for an intermittent or spasmodic contraction of the sterno-mastoid, and it may be of associated muscles.

(5) *Postural wryneck*, arising secondary to deformities of the spine, or in compensation for an ocular error.

(6) *Paralytic wryneck* following paralysis of the trapezius and sterno-mastoid muscles. The usual cause is division of the associated nerves during operation for tuberculous cervical glands

All varieties are met with in childhood, but the congenital type forms the great bulk of the cases.

Congenital Wryneck

The condition may be defined as a unilateral contraction of the sterno-mastoid muscle with adaptive shortening of the related fasciæ and muscles, the result being a characteristic attitude of deformity in which the head is inclined towards the affected side, and rotated towards the sound side.

CLINICAL HISTORY

In many of the cases, the first evidence of the disorder is the appearance of an elongated and rounded swelling involving the lower third of the sterno-mastoid muscle. At first the swelling is tender to touch, but this feature subsides, and the condition is apparent as a firm, fusiform thickening, which is continuous with the outline of the muscle. This original swelling subsides, and, if the parents are not particularly observant, it may have passed unnoticed, but when the child is a year old the muscle at its site undergoes a degeneration into a band of dense fibrous tissue. This demonstrates the changes common to acquired fibrosis in any situation; it begins to contract, and by so doing the muscle is progressively shortened in length. Secondary to the shortening the head is pulled into the characteristic attitude so that the ear is approximated to the shoulder on the side of the affection, while the face is rotated towards the opposite side. The persist-

ence of the deformity for any length of time is associated with an atrophy of the facial muscles on the side of the contraction, so that the face acquires a characteristic appearance—in infants this change is not marked, but as the child grows older it becomes more evident, fortunately, the asymmetry disappears after correction of the deformity.

In the absence of treatment the shortening increases until the deformity becomes extensive, contraction of an adaptive nature becomes manifest in the surrounding associated structures, and in a long-standing and severe case the bones of the cervical and upper dorsal spine acquire a fixed scoliotic deformity.

ETIOLOGY

A good deal of uncertainty surrounds the question of the origin of the deformity, but certain facts are known beyond question. The error may be hereditary (and in this connection it is interesting to observe its occasional co-existence with such malformations as club foot and congenital dislocation of the hip), or a history of delivery by forceps is often forthcoming. While in the majority of cases the contraction is a unilateral one, in a small proportion a double lesion has been reported.



343—Congenital Wryneck of the left Sterno-mastoid (Girl 8 years)

To explain the facts certain theories have been formulated.

(a) *The Traumatic Theory* This view is associated with Stroe-meyer's name, and is the most commonly accepted one. It is supposed that the sterno-mastoid muscle is ruptured or injured during labour, that scar tissue develops, and that the contraction of this produces the characteristic changes in the muscle.

But this view has discrepancies which it is difficult to explain. 'A ruptured muscle does not contract, it lengthens, microscopical examination of the muscle shows no evidence of trauma, and it certainly does not explain the example of the disease which has been met with in association with an extra uterine gestation' (Joachimsthal and Volcker).

(b) *The Infective Theory.* Mikulicz and Kader have advanced the view that an infective myositis is the basis of the error, the infection being possibly associated with a preceding trauma of the muscle. No real evidence, however, has been brought forward to confirm this theory.

(c) Another theory attributes the condition to *intra-uterine disease*, and in particular to congenital syphilis. It is true that syphilis may be associated with sclerotic changes in muscle and the sterno-mastoid

is liable to be involved in common with others, but syphilitic sclerosis does not induce muscular contraction, and there are many cases of wryneck in which no possibility of syphilitic infection can be entertained.

(d) There have been suggestions that a wryneck may be the result of a *nerve paralysis*, but the difficulties in accepting such a suggestion are insurmountable.

(e) *An Ischæmic Theory* has been advanced, and in the opinion of many it offers a satisfactory explanation of the problem. It is certain that there is a resemblance between the pathology of a muscle affected by wryneck and the muscle which is affected by a Volkmann paralysis; such a theory would also explain the



FIG. 344.—Congenital Wryneck.

There is a congenital wryneck of the left sterno-mastoid, the asymmetry of the face is characteristic

partial distribution of the lesion and the absence of primary involvement of the surrounding parts.

The clinical and experimental work of Nove-Josser and Vianny has put this theory on a reasonable basis. Assuming that the sternal and middle portions of the sterno-mastoid muscle are supplied by the sterno-mastoid branch of the superior thyroid artery, this vessel has, comparatively speaking, little or no anastomosis with adjacent vessels, and in this respect resembles an "end artery." If the circulation in this vessel is obstructed, it is supposed that an ischæmic

change will appear in the area of muscle which it supplies, and it is believed that if the head of the foetus is distorted in utero so that there is lateral flexion of the head with torsion of the neck, a vascular obstruction is thereby produced. The authors of this theory have demonstrated the interesting fact that in every case of wryneck which they examined the lumen of the sterno mastoid artery was obliterated at the anterior border of the muscle.

Sippel¹ has lately contributed observations on thirteen children born with wryneck. He supplies evidence of the position of the foetus in the uterus, in order to show that the changes in the sterno mastoid muscle are the result of the head of the foetus being turned to one side so that the point of the shoulder on that side is pressed into the neck. The pressure produces an atrophy and contraction of the muscle especially in its lower part, there is also an atrophy of the overlying platysma. Forceful straightening of the head during birth causes hæmorrhage into an already atrophied, partially fibrosed, and contracted muscle, with subsequent tenderness and swelling of the part. If there is no harmful strain upon the part during birth, the torticollis is solely attributable to the abnormal pressure upon the muscle towards the end of intra uterine life.

PATHOLOGY

The pathological changes are primarily confined to the lower end of the sterno mastoid muscle. The deep cervical fascia undergoes a thickening and contraction. A secondary adaptive shortening becomes apparent in the muscles related to the sterno mastoid and particularly in the scalenus anticus and medius. If a portion of the muscle is excised during the stage of swelling and submitted to a microscopical examination, the affected area exhibits atrophy of the muscle, some of the fibres showing degeneration into a homogeneous substance with loss of both longitudinal and transverse striation. There may be an infiltration of blood throughout the tissue. At a later stage a fibrosis appears among the muscle fibres, and it extends until there is almost complete disappearance of muscular tissue. It is the progressive contraction of the fibrous tissue which gives the characteristic clinical appearance of the disease.

The changes may affect both sternal and clavicular heads of the muscle in equal degree, sometimes one head only is involved. No microscopical change is apparent in the related muscle.

CLINICAL FEATURES

In an early case, swelling of the lower end of the muscle may be the only change which is apparent. In a well established case, the sterno mastoid muscle is replaced by a fibrous cord, which is often no thicker

¹ Sippel P. Der Angeborene Muskuläre Schiefhals. *Deutsch. Zeitsch. für Chir.* 1920 155 1

than a lead pencil. If the head is straightened the muscle stands out prominently. The shortening which the muscle has undergone results in the characteristic distortion of the head already described. In addition there are a number of associated changes—the face on the affected side is flattened, and its muscles atrophied, there is often a squint of the eye on the side corresponding to the lesion, the skull over the region of the temporal bone may be flattened or even depressed, the ear may be distorted, and its lobule pushed up, and there may be contraction of the field of vision owing to the forward direction of the eyes in a head which is otherwise distorted in position. With



FIG. 345.—Congenital Wryneck.

Anterior and posterior views of a congenital wryneck of the left sterno-mastoid muscle. The posterior view illustrates the development of a cervico-dorsal scoliosis.

the distortion of the head there may be a scoliotic deformity of the cervical and upper dorsal spine.

DIAGNOSIS

There should be no real difficulty in the recognition of a congenital wryneck. Doubt may arise at the stage when the muscle is the site of swelling, but in its contracted and fibrotic state there can be no dubiety. Considerations of diagnosis will include the recognition of the different varieties of . . . the history and the cord-like condition of the muscle . . . characteristic of the congenital . . . ty.

TREATMENT

An infant born with wryneck requires active treatment forthwith. In a slight case it is sufficient to arrange for massage and movement of the head so as to stretch the shortened muscle. In more marked cases the fibrosed and contracted portion of the muscle should be excised as soon as the child is one month old. The site of the wryneck is thus removed before secondary and adaptive changes appear.

There are many cases, however, which are only brought to the surgeon's notice when the child is five or six years of age, by this time the muscle is a dense fibrous cord, and operative measures are necessary.

The principles which guide one in undertaking operative measures are to divide completely the muscular and fascial bands which prevent restitution of the head, to maintain the head in a correct position after operation, and to ensure a course of after treatment which will prevent recurrence of the deformity and at the same time correct any compensatory error which has appeared.

Operation The division of the muscle and the associated shortened structures may be carried out by a subcutaneous tenotomy or through an open incision.

Subcutaneous Tenotomy This method has disadvantages, two of which are outstanding. While tenotomy of the shortened muscle may be simple, it is difficult and in some respects impossible to ensure severance of the other shortened structures, more especially of the cervical fascia and the scalene muscles. The second disadvantage is the danger of injuring the internal jugular vein which lies adjacent to the posterior surface of the sterno mastoid. There is a very real risk that a misdirected division of the muscle may injure the underlying vessel.

If this operation is the method of choice it is carried out at the lower end of the muscle close to its origin. Each head is divided independently, the sternal head being first severed. The overlying skin is pinched up between the finger and thumb, and a puncture is made with a fine sharp-pointed tenotome, into the puncture so made a blunt-pointed tenotome is inserted, and its cutting edge is brought into contact with the anterior edge of the muscle. With a steady sawing movement the band is divided from within outwards, *the muscle being kept tense throughout the process of division*. A second puncture is made in a similar fashion over the clavicular head, and division is then completed. A deep hollow now appears at the point of severance, and by pressing the finger into the hollow any persisting fibres are broken. The head meantime is forcibly placed into a corrected position, and by this manoeuvre a further stretching or actual tearing of shortened structures is ensured. A small pad is placed so as to occupy the hollow, and it is secured in place by an adhesive strapping. The after-treatment of the case is similar to that followed after open division.

Open Myotomy This method has the advantages of safety and

completeness ; each of the structures to be shortened is brought under review, and division secured. The scar is the only objection to the operation, but it is of minor consequence.

The Operation A narrow sandbag or pillow is placed beneath the shoulder, so that the head falls back, thus bringing the shortened muscle into prominence. An oblique incision is made across the prominent heads of the muscle, but in doing so the skin should be pulled downwards with the finger-tips so that the incision is actually made over the sterno-clavicular articulation ; when the skin is allowed to resume its position the incision is found to lie over the muscle. If a direct incision is made the irregularity of the surface is such that the wound is an uneven and irregular one. The lateral division of the anterior jugular vein is exposed and ligatured. By dissection, the outlines of the muscular heads are defined, a flat dissector is slipped beneath the deep surface of the muscle, and each head is divided on the dissector ; by this method there is no risk of damaging the underlying internal jugular vein.

Retraction of the divided muscle exposes the deeper portions of the wound, the deep cervical fascia is divided on each side of the muscle line, and the omohyoid muscle is exposed and defined—its division is rarely required. The carotid sheath is frequently affected ; it is therefore defined, separated from the underlying vein, and divided. Great care is demanded in this stage of the operation. By retraction of the vein inwards the scalenus anticus is exposed, and if it shows any evidence of fibrosis and shortening it should be divided.

Throughout each step of the operation steady pressure is kept on the head, so as to bring any shortened structures into prominence. Drainage of the wound is to be avoided, and therefore complete hæmorrhage is ensured. The wound is closed by a subcuticular suture or by interrupted sutures. As it is impossible to stitch any of the deeper structures, and as a considerable subcutaneous cavity necessarily exists for some time, it is essential that the cutaneous wound be made as strong as possible ; we therefore employ a removable cutaneous suture in preference to a subcuticular absorbable one. The operator will find difficulty in preventing the inversion of the skin edges, and therefore a series of vertical mattress sutures is used, with firm horse-hair sutures in the intervals ; by these means broad surfaces of apposition are secured, and there is no danger of the wound gaping.

A dressing is applied which maintains the head in an over-corrected position, that is to say, the ear approximates towards the shoulder on the healthy side, while the face is turned towards the affected side. The child is nursed on its back, and sandbags are placed to steady the head in the correct attitude.

AFTER-TREATMENT. Whatever type of operation is adopted, it is only the first step in treatment, for completion of the cure depends upon the subsequent handling of the case.

After fourteen days the corrective bandage is removed, and a

poroplaster collar is fitted. It rests upon the shoulder, encircles the neck, and above it is accurately fitted around the mastoid process over the occiput and above the ears, while a forehead strap holds the head in position. This collar is removed each day so that active and passive movements may be carried out. It is obvious that a great deal of the success of treatment depends upon the conscientiousness with which these movements are practised. This plan of treatment is continued for six months. If the case has been an especially severe one, and if it is found that there is a tendency for the deformity to recur in spite of the use of the collar, an appliance should be fitted which permits of elastic traction upon the head (see diagram).

Other Rare Varieties of Congenital Wryneck. In addition to the common anterior variety of wryneck which we have described there are other rarer types of congenital contraction which are grouped under the term wryneck. Their incidence is so uncommon that only the briefest notice of their occurrence is necessary.

Posterior Wryneck

A posterior wryneck is sometimes met with, in association with the deformity of congenital elevation of the scapula (Sprengel's shoulder). The contracture affects the trapezius, the levator scapulae, and the deeper cervical muscles. The head is tilted backwards, and the face is turned towards the side of the deformity.

Operative treatment is not advisable. The best results are obtained by repeated stretching under anaesthesia, and by the wearing in the intervals of a corrective collar.

Lateral Wryneck

A lateral congenital wryneck has been described and illustrated (Dollinger). The trapezius and the sterno mastoid are shortened, and as a congenital error of the cervical spine always accompanies the soft tissue contraction, it is probably correct to consider the osseous error as the primary cause of the contraction.

Double Wryneck

Several examples of double wryneck have been described. Both sterno mastoid muscles are shortened so that the chin points forward and the head is sunk into the neck.

Acute Wryneck

This variety of wryneck is frequently met with in children in association with acute infective conditions of the cervical glands. It responds to the ordinary methods of treatment, hot applications to the neck are the most comforting and efficacious.

Spasmodic Wryneck (*Spastic torticollis*)

The condition is apparent as soon as the child is brought under observation. The head is suddenly and violently pulled to one side

while the face is turned towards the opposite side, and the greater the attention paid to the patient the more violent do the spasms become. The facial muscles, the muscle of the floor of the mouth, and even those of the shoulder may be affected by the contraction.

The movements are sometimes intermittent and clonic, at other times persistent and tonic. In a typical case one sterno-mastoid and the posterior cervical muscles of the opposite side act together.

It is uncertain whether the situation of the disease (which must be looked upon as a neurosis) is exclusively in the cerebral cortex or in the more deeply placed centres of co-ordination: possibly both are involved. Various peripheral irritations may originate the stimulus, as, for example, errors of refraction, carious teeth, sinus suppuration; a habit spasm may eventually become a variety of spasmodic wryneck.

TREATMENT. Sedative drugs and the use of massage and electricity may be tried. The surgical measures which have been carried out are stretching or neurectomy of the spinal accessory nerve, neurectomy of the posterior primary divisions of the upper five cervical nerves, division of the various affected muscles and retention in an apparatus, and operation on the cortical centres.

TUBERCULOUS CERVICAL ADENITIS

Tuberculosis of the cervical glands is one of the common surgical affections of childhood. The disease is peculiarly frequent in certain localities, and local conditions afford the explanation of its high incidence, but, generally speaking, it is widely distributed.

ETIOLOGY

A number of secondary features affect the incidence of the disease, and these are considered individually.

Age. We have recently carried out an analysis of the age incidence of the disease as apparent in a group of 300 patients of twelve years old and under; the results are expressed in the following table:—

TABLE OF AGE INCIDENCE

<i>Years</i>								<i>Numbers</i>
To	1 year	.	.	.	.	.	.	30
From	1 to 2	.	.	.	.	.	.	27
„	2 to 3	.	.	.	.	.	.	50
„	3 to 4	.	.	.	.	.	.	48
„	4 to 5	.	.	.	.	.	.	21
„	5 to 6	.	.	.	.	.	.	31
„	6 to 7	.	.	.	.	.	.	28
„	7 to 8	.	.	.	.	.	.	25
„	8 to 9	.	.	.	.	.	.	19
„	9 to 10	.	.	.	.	.	.	14
„	10 to 11	.	.	.	.	.	.	15
„	11 to 12	.	.	.	.	.	.	9

From this record it is apparent that the majority of the cases manifested themselves during a period extending from birth up to the fifth year, in fact, one half of the cases could be grouped into this period.

An explanation of the peculiar age incidence is not far to seek, for the age period corresponds to one in which the child is liable to come into contact with the organisms of the disease through the medium of infected milk, while the lymphatic system is profuse, highly active in its absorptive function, and yet only partially educated in the properties of resistance.

Type of Bacillus The suspicion that a bovine strain of infection preponderates in tuberculous cervical adenitis has been confirmed by the evidence of recent investigation. One of the most instructive proofs in this connection has been brought forward by Mitchell. In a large series of cases he found that 90 per cent of the infection arose from the bovine type of organism, and these results have been confirmed by other observers.

In practice a bovine infection is synonymous with infection by milk, and there can be no doubt that an impure milk supply is the factor of greatest influence in the development of glandular tuberculosis. In a relatively small proportion of cases, the human strain of bacillus is found, and in these cases it is often possible to trace a history of contact with a victim of pulmonary tuberculosis.

Portals of Entry and Routes of Infection When a lymphatic gland is infected with tuberculous disease, the organisms have been carried to its interior by one of two possible routes—by the lymph stream or by the blood stream. Each of these demands consideration.

Lymphatic Infection A lymphatic infection presupposes a portal of entry in the field from which the lymph has drained, and there are three areas which for anatomical and physiological reasons are the chief centres of original infection—(1) the faucial tonsils, (2) the lymphoid tissue of the naso-pharynx (adenoids), and (3) the teeth.

The first and second of these are especially important, for they are sites of high absorptive possibilities, while the crypts and the follicles of the tonsils are 'nidi,' in which organisms are constantly being retained. It is a mistake to suppose that when tissues of this description are the original fields of infection they necessarily show evidence of disease, in some instances they undoubtedly do so, but in a considerable proportion of cases they harbour the organisms and permit of their passage into the lymph stream without themselves becoming attacked.

Too little attention has hitherto been paid to the possibilities of infection from the teeth in this connection. When caries attacks a tooth and the pulp is exposed, tubercle bacilli are frequently harboured in the interior, and from this focus a lymphatic infection arises which is manifested later as tuberculosis of the sub-maxillary lymphatic glands.

Blood Infection A certain proportion of children who develop

glandular tuberculosis are already the victims of tuberculous septi-cæmia, and in these cases the blood stream may be the route along which the infection has travelled. In such instances one may have to look far afield for the portal of entry. It may be that the disease has gained entrance through the intestinal tract, giving rise to tuberculosis of the abdominal glands and thence infecting the blood stream, or that the bronchial glands or the hilum glands are diseased. A tuberculous focus in any region of the body, however remote, may be the focus of entry of a blood infection.

Predisposing Infections.—It is recognized that any pre-existing disease which lowers the general body resistance may have a predisposing influence upon the development of glandular tuberculosis.



FIG. 346 —Glandular Tuberculosis.
Tuberculous disease of the right sub-maxillary
group of lymphatic glands

Where children are concerned the influence of the exanthemata is manifest in this connection, for not only is the body resistance lowered, but the local glandular resistance is affected by the absorption of toxic and absorptive products from the various catarrhs which accompany most of the infective diseases of childhood.

SURGICAL ANATOMY

Poirier and Cunco have suggested that for descriptive purposes it is convenient to divide the cervical lymphatic glands into two groups—a circular chain which surrounds the base of the skull, and a series of vertical chains which lie in the line of the long axis of

the neck. *The circular chain* forms an interrupted girdle of lymphatic tissue. Beginning in the middle line in front, the *sub-mental glands* lie between the anterior bellies of the digastric muscles, deriving lymph from the skin of the lower lip and chin and from the mucous membrane of the tip of the tongue and the anterior part of the floor of the mouth. Next in order come the *sub-lingual glands*, situated between the genioglossi muscles upon the hyoglossus, and connected by lymphatics with the under surface of the tongue and the floor of the mouth. Farther back the *sub-maxillary glands* lie in the digastric triangle between the mandible and the salivary tissue, their lymphatics being derived from a wide area comprising the anterior part of the face, the inner half of the conjunctiva, the orbit, the nose, the mucous membrane of the mouth, including the teeth and gums, and

the anterior part of the tongue. The *facial gland*, which lies on the outer surface of the mandible, is associated with this group.

There are three sets of glands in the immediate neighbourhood of the ear—the *anterior auricular*, the *posterior auricular*, and the *parotid*. The first and second of these are fed from skin surfaces, and their infection is therefore uncommon, the *parotid* group, on the other hand, is buried in the substance of the *parotid salivary gland* except for a special process of the group which passes into the neck along the external jugular vein (the *superficial cervical*, the *sub auricular*, or *external jugular gland*), and receives its lymph from the inner surface of the outer ear, from the *middle ear*, the *nasal fossæ*, and the skin of the side of the head. The chain is completed by the *occipital glands*, lying along the superior curved line, superficial in their lymph connection, and by the *retro-pharyngeal glands*, which lie behind the mucous membrane of the pharynx on the pre-vertebral fascia. Of the circular chain three groups are particularly important in so far as they are the most common sites of tuberculosis—the *sub-maxillary*, the *parotid*, and the *retro-pharyngeal glands*. Each has a lymphatic field distribution on a mucous surface which is peculiarly liable to the lodgment and entrance of tuberculous material.



FIG. 347.—Tuberculous Cervical Glands

Disease of the anterior and posterior groups of the left side. Note the lateral displacement of the upper portion of the sternomastoid muscle the result of underlying tuberculous disease.

The series of *vertical chains* may be divided into three—an anterior, and a right and left lateral. The *anterior chain* is of little pathological significance. It lies in a superficial position in the middle line of the neck, and from above downwards it comprises the anterior jugular, the pre laryngeal, the pre tracheal, and the para tracheal glands.

The *lateral chains* are the largest and the most important of the various collections of cervical glands. Each lateral chain is divided into an *upper* and *lower* division by the line of the omohyoid muscle, and each of these is again subdivided into *anterior* and *posterior* groups according to their relations with the great vessels of the neck. Of the four groups so constituted the *upper anterior* is the most important, because it is the one most frequently affected by disease. It receives lymphatics from the *naso pharynx*, including the *faucial* and *pharynx*.

geal tonsils, and indirectly through the circular chain from the various fields with which the circular chain is associated. The lymph from the faucial tonsil is particularly distributed to a special gland of the group, which occupies the triangle formed by the posterior belly of the digastric muscle and the common facial and internal jugular veins, the *jugulo-digastric gland* (Wood's gland). The *lower anterior group* continues the chain downwards into the mediastinum, and it is in lymphatic communication with the glandular group immediately above and with the larynx, the trachea, the œsophagus, and the thyroid gland. The *upper posterior group* lies behind the internal jugular vein upon the splenius cervicis and the levator scapulæ muscles, and the spinal



FIG. 348.—Tuberculous Disease of Cervical Glands

Tuberculous disease of the anterior and posterior carotid groups of cervical glands

accessory nerve runs through its centre. Lymphatics from the pharyngeal tonsil enter the group on its deep surface, while there is an indirect communication with the glands of the anterior group and with the posterior auricular and the occipital glands. The *lower posterior group* is a continuation of the upper posterior group, it lies upon the levator scapulæ and the scalenus medius muscles behind the internal jugular vein, and, continuing downwards, it becomes the supra-clavicular group, which again is subdivided into a superficial and a deep collection through the medium of the omohyoid muscle and the deep cervical fascia. The afferent lymphatics to the lower posterior group proceed from

the glands of the upper posterior group.

The Glands affected by Disease. Of the various groups of glands which lie in the neck four are especially liable to be affected by disease, these being the sub-maxillary and the parotid groups of the circular chain, the superior anterior and the superior posterior groups of the vertical chain. The special liability of these glands is dependent upon the areas from which their lymph is drained—the tonsils, the adenoid tissue of the pharynx, and the teeth. The highest individual incidence of disease occurs in the jugulo-digastric gland of the anterior superior chain, the focus of lymph absorption from the faucial tonsil. This is the site affected in 80 per cent. of cervical glandular tuberculosis.

Changes in individual Glands. The average lymphatic gland

is somewhat kidney shaped in outline. At the hilum blood-vessels enter and leave the gland, and efferent lymphatics emerge, the afferent lymphatics pierce the capsule to enter the gland at various sites around the convexity.

The gland capsule is a covering of fibrous tissue, and from its deep surface septa dip inwards so as to subdivide the gland into a series of incomplete divisions. Between the lymphoid tissue of the interior and the fibrous capsule with its indipping processes there is a narrow channel bridged across with strands of connective tissue—the 'corridor' of the gland.

The scheme of the lymph flow is so arranged that the stream enters by the various afferent vessels along the convexity, circulates through the 'corridor,' permeates the lymphoid tissue and emerges from the hilum by the various efferent channels. A proper appreciation of these details is essential if the pathology is to be understood.

Recognizing that the gland may be infected by way of the blood stream or by way of the lymph stream, the situation of the original tubercle varies according to the route which the infection has followed. In the case of blood in-



FIG 349.—Tuberculous Disease of the left Cervical Glands

The anterior upper carotid group are affected and the condition has passed on to abscess formation

infection the disease is first manifest in the centre of the gland, for it is there that the larger vessels break up into their ultimate capillary distribution, on the other hand a lymphatic infection is generally first apparent in the gland corridor, where the interlacing septa of connective tissue are of the nature of filters which arrest the organisms in their course.

In the early stages of the disease, the tuberculous follicle appears as a greyish white nodule set in the background of the healthy gland tissue. Several follicles are apparent, and they coalesce until an appreciable focus is visible. Within a comparatively short period of

time ; caseation develops in the interior of the follicle, and an intra-glandular tuberculous abscess results.

The process thus begun has a constant tendency to spread, the tuberculous infiltration extending around the periphery, while the softening and pus formation coincidentally develop in the interior. The disease progresses until the capsule of the gland is reached, and for a time the fibrous barrier limits the further spread, but it is soon perforated, and the escape of caseous debris to the periglandular space forms a periglandular tuberculous abscess. This is the signal for a series of reactive changes in the soft tissues which surround the gland ; the parts become cedematous, infiltrated, and adherent. If the gland is a superficial one, the tuberculous debris makes its way into the subcutaneous space, the deepest layer of the skin becomes affected,

and a destructive process ensues until only a thin pellicle of epithelium overlies the abscess. When this gives way, a sinus is established, through which the tuberculous matter escapes to the surface.

The microscopical changes which accompany the gross pathology are well recognized ; apart from the histological appearance of the actual tuberculous tissue, the various constituents of the gland show distinctive changes—the connective tissue increases at the



FIG. 350 —Tuberculous Disease of the left anterior Carotid Group of Cervical Glands.

A subcutaneous abscess has developed

expense of the lymphoid tissue, and the gland therefore becomes more fibrous in consistency ; in the more chronic types of the disease this change may be manifest to a striking degree. The endothelial cells which line the lymph sinuses proliferate.

Periadenitis. In the course of the tuberculous process there are exacerbations, when the clinical features seem to resemble those of a sub-acute inflammatory lesion. The gland becomes enlarged, tender to touch, and indistinct in its outline, cedema developing in the surrounding tissues. To these incidental changes the term 'periadenitis' is applied. The development is most likely the result of a superadded pyogenic infection developing in a gland already devitalized by the existing tuberculous process. It is an item of considerable clinical importance, because it is frequently the stimulus which results in a more rapid spread of the tuberculous infection.

DISTINCTIVE TYPES OF GLANDULAR TUBERCULOSIS

It is possible to differentiate three varieties of glandular tuberculosis as judged from a pathological basis—the caseous, lymphoid, and fibrous types

The caseous type of the disease is that most frequently met with, its distinctive character being the softening and cold abscess formation which develop with the tuberculous infection

The lymphoid type is apt to be mistaken for lymphadenoma. The glands remain discrete, there is little or no periadenitis, and if caseation occurs, it is a late manifestation. The distinctive histological feature of this variety is an excessive proliferation of the endothelial cells of the lymph sinuses

The fibrous type is more common in the adult than in the child. The glands are small and hard, with points of central caseation, adhesion to the surrounding tissues is an undesirable peculiarity of this variety

CLINICAL FEATURES

It is characteristic of many cases of glandular tuberculosis that, apart from the actual swelling of the gland, there may be comparatively few clinical evidences. In some instances, the glandular enlargement is preceded by a tonsillitis or by a general body infection such as measles, influenza, or scarlet fever, in the majority of cases, however, no precurrent infection can be demonstrated

While the glandular enlargement is usually of such a gradual and insidious character that it is eventually discovered by chance, it may happen that the first manifestations are of an acute nature, the gland becoming enlarged, diffuse and indefinite in its outline, and tender to touch. There are signs of general illness—in fact, all the characteristics of a simple acute adenitis. When this stage subsides the glands remain enlarged. In whichever way the process has begun, the tendency is for the enlargement to progress, glands in the immediate



FIG. 351.—Tuberculosis of the Cervical Glands
Disease of the anterior carotid or jugulo-digastric group

neighbourhood becoming affected, until a swelling of considerable size has developed. At intervals the occurrence of periadenitis is apparent, when the glands become tender, swollen, fixed in position, and indefinite in outline. For a time the enlargement is firm and uniform, but in the average case a stage is reached when caseation develops in the interior, becoming apparent clinically as a boggy and semi-fluctuating area in the gland outline. With the development of a periglandular abscess, the clinical features alter—the swelling increases, the regular outline of the glandular enlargement is lost, and the tissues become fixed and ill-defined. As the caseation makes its way to the surface, the overlying skin becomes reddened, and as the pus accumulates the skin is gradually undermined and destroyed until it forms a thin transparent pellicle. When



FIG 352—Tuberculous Lymphadenitis

There is extensive tuberculous disease of the circular chain of lymphatic glands with tuberculous ulceration of the overlying skin. The vertical groups of glands are also involved.

this covering gives way a sinus is established, and as the skin which surrounds the sinus is infiltrated with tuberculous disease a tuberculous ulceration may be said to exist. In the absence of surgical treatment the sinus continues to discharge as long as the underlying gland remains active—it may continue for a prolonged period, becoming arrested when the gland has cicatrized into a hard fibrous nodule.

The evidences of the disease are not limited, however, to the local manifestations, other features appear which are due to absorption of toxic products from the glands. The general appearance of the child deteriorates, there is loss of weight, a careful record of the temperature may show a slight evening rise, the child becomes cross, irritable, and easily tired, and the appetite for food is lessened.

The Examination. By ordinary methods of palpation the group of enlarged glands is examined. Each region of the neck is brought under review, and a general examination is made of the other gland areas of the body—the axillæ and the groin. The glands which are actually affected are investigated for evidences of caseation, of abscess formation, of periadenitis, and of fixation. Information on these various points is necessary before treatment can be recommended. Attention is paid to the surface area from which the affected glands have derived their lymph supply—the teeth, tonsils, adenoid tissue

of the naso pharynx, and the ear are examined in turn. The body generally is overhauled in order to ascertain whether a focus of disease exists in any other part, the chest is investigated, and an X ray examination of the mediastinum is carried out. The abdomen is palpated and X rayed with a view to ascertaining whether tuberculous glands exist there, the extremities are examined for evidences of tuberculous lesion of the bones or joints. In every case the milk history and the family history demand inquiry.

DIAGNOSIS

Tuberculosis is the commonest cause of an enlargement of the cervical glands which has persisted over an appreciable length of time. In a characteristic case the diagnosis is comparatively easy—there is the gradual enlargement of the glands, the absence of pain except during the occurrence of an attack of periadenitis, and the common sequel of caseation, as evidenced by softening and abscess formation. It is the demonstration of this last point, accompanied as it may be by the opportunity of obtaining pus through an aspirating needle, which makes the diagnosis clear.

Difficulty occasionally arises in the distinction of the following conditions—

- 1 Simple acute or sub acute adenitis
- 2 Simple chronic adenitis
- 3 Lymphadenoma
- 4 Lymphosarcoma

1 Simple Acute or Sub-acute Adenitis Because a certain proportion of tuberculous cases have an acute beginning it may be difficult in the early stages to distinguish between simple and tuberculous adenitis. Fortunately an immediate diagnosis is unnecessary where treatment is concerned, and the natural effect of time is to clear up the problem, for the simple case subsides and the glandular enlargement disappears, while the tuberculous case persists after the acute introduction has subsided. If abscess formation has occurred in



FIG 353.—Tuberculosis of left posterior Carotid Group of Glands (Boy 4½ years)



FIG. 354.—Sarcoma of Neck (Girl 4½ years)
Microscopical examination showed the tumour to be
lympho-sarcomatous in type

either variety, aspiration and bacteriological examination of the fluid is decisive.

The semi-epidemic form of cervical adenitis known as '*glandular fever*' is sometimes confused with tuberculosis, but the fever, the bilateral distribution, the tender character of the enlarged glands, and the usually associated tonsillitis are generally sufficiently distinctive of the first-mentioned condition.

2 Simple Chronic Adenitis, Chronic Glandular Hypertrophy. An enlargement of the cervical glands,

which in some respects resembles tuberculosis, may proceed from a long-continued absorption of infective material, hence the glandular swelling which accompanies enlarged tonsils and adenoids, caries teeth, and scalp impetigo. The recognition of this clinical condition is made when it is found that the enlargement does not progress, and that when the source of irritation is removed the enlargement disappears.

3. Lymphadenoma.

Hodgkins' disease is characterized by the widespread distribution of the affection, by the absence of periadenitis, by the tendency which there is for individual glands to remain separate and discrete, by the absence of softening or abscess



FIG. 355—Lympho-sarcoma of the Cervical Glands in a Child six years old.

The tumour grew with great rapidity, and within two months of the first appearance of swelling the child was dead.

formation, and by the secondary anæmia with its accompanying symptoms

4 Lymphosarcoma Tumours of this description are recognized by their rapid growth, infiltrating edge and the severe pain

In exceptional cases there are other possibilities which have to be considered in the differential diagnosis—such as syphilitic adenitis, and the glandular enlargement of lymphatic leukæmia

PROGNOSIS

Cervical glandular disease is one of the least dangerous of the many forms of tuberculosis

It possesses this favourable aspect because the tendency is for it to remain localized to the lymphatic tissue, and being situated in the neck, it is not in direct contact with such vital structures as the intestine or the lung

The prognosis is affected by the answer which is given to the question, 'Has the infection been lymphatic or blood borne?' In the former instance, as typified by disease of the cervical glands secondary to infection through the tonsil, the prognosis is good, because the glandular disease is but a local manifestation of a local disease, and for some



FIG 356—Tuberculosis of the Cervical Glands (Boy 7 years old) with widespread tuberculous infection of the Cervical Glands

Evidently an example of a blood infection

time at least it remains in this category. Blood infections, on the other hand, presuppose a tuberculous septicæmia, and the future outlook is correspondingly imperilled, therefore the association of cervical disease with a tuberculous lesion in another part of the body, the irregular distribution of the tuberculous disease in the neck, the central manifestation of the disease in the gland, all evidences suggestive of a blood infection in contrast to a lymphatic infection tend to increase the gravity of the prognosis

Other factors in the prognosis are those of age and position. The development of the disease during the first two years of life is especially

serious, because at this period it tends to run a rapid course, and death by tuberculous meningitis is frequent.

In regard to the question of position—affection of the jugulo-digastic group is the most favourable, because it is likely to be a local manifestation of infection through the tonsil; disease of the posterior chain is unfavourable, because of the possibility of the development of a retropharyngeal abscess; disease of the supra-clavicular group is associated with the danger of secondary infection of the mediastinum or the lung.

TREATMENT

There are few subjects in which such diversity of opinion has been expressed as in the problem of how best to deal with glandular tuberculosis, and it is unlikely that uniformity of opinion will be reached unless a specific remedy for tuberculosis is discovered. As the position is at present, it may be said that there are three separate views:—

1. That all cases of this disease should be treated by medical and conservative means, the only surgical treatment permissible being aspiration of an abscess if such develops.
2. That whenever the diagnosis is confirmed as being one of glandular tuberculosis a radical excision of the affected glands should be performed.
3. That in the early stages of the disease an opportunity should be given for conservative measures to effect improvement, and if possible a cure, but under certain well-defined indications surgical treatment should be resorted to as offering the best possibilities of cure.

It is unnecessary to elaborate the various arguments which have been put forward in favour of or in opposition to the various views. It will be sufficient to outline the principal features of conservatism, to detail the conditions which are accepted as indicating operation, and to describe the important features of a typical operation.

Conservative Treatment

The principle which underlies this line of treatment is so to increase the natural resistance of the body by general and local means that natural arrest of the disease is secured. The various measures adopted under this scheme so increase the local vascularity and resistance that barriers of fibrous tissue are deposited around the diseased focus, the effect being to isolate the disease, to cut it off from its nutritional blood supply, possibly even to strangle it by mechanical constriction, and eventually to convert it into a knot of fibrous or calcified tissue.

General Treatment. In such a scheme as this, general hygiene plays a most important part. It is therefore arranged that the child is put under the best possible conditions, with fresh air in abundance,

a moderate amount of healthy exercise, and a liberal diet containing a high proportion of the animal fats. A careful search is made for any focus of peripheral irritation which might be responsible for devitalizing the gland, special attention therefore is paid to the teeth, the tonsils, and the ears.

Local Conservative Treatment A great variety of methods of treatment under this heading have been brought forward, but only those of proved value are detailed.

(1) *Hot Fomentations* This simple remedy plays an important part in the local treatment, but its use is limited to the stage of periadenitis. When a tuberculous gland becomes tender, enlarged, fixed and indefinite in outline, the application of repeated hot boracic fomentations produces a marked improvement. The substitution of a hot saturated solution of magnesium sulphate for the simple boracic solution is sometimes of value. The treatment should not be continued after the periadenitis has disappeared.

(2) *Local Skin Applications* These are among the most popular of the methods of local treatment, but it is questionable if any of them are of actual value. Iodine, iodox, and the mercurial ointments are the most favoured applications, and it is conceivable that as counter irritants they may induce a slight local improvement, but it is unlikely that they possess any selective influence upon the gland. The ointment of allyl sulphide was thought at one time to have a specific curative effect, but the claim has not been justified. One disadvantage is common to all local applications—they may so irritate the skin that if operative interference becomes necessary, the local conditions are rendered less favourable.

(3) *Congestive Treatment* A modification of Bier's congestive treatment has been used, and a certain amount of success has been ascribed to it. Vacuum cups (Klapp) are applied over the glands for a period of one hour twice daily. The method has the disadvantage which is common to all types of Bier's treatment as applied to tuberculosis—it appears to hasten the development of cold abscess formation. Bier claims "that the development of suppuration need not be accepted as an indication to modify the treatment, for he advises that the abscess be opened, and the suction continued over the position of the sinus."

(4) *X rays and Radium* The literature is full of accounts of the cures produced by means of radium and X rays, either separately or combined. They have a definite sphere of usefulness in the 'lymphoid' type of glandular disease, but they have no influence upon an infection which has passed on to caseation. If operative interference is likely to become necessary the use of X rays is to be discouraged, because of the extensive adhesions which result from the treatment.

(5) *Heliotherapy—Artificial and Natural* This is one of the most useful conservative procedures. The value of its effects is undoubted, while it has none of the disadvantages which are associated with

X-ray treatment. The details of its technique have been described (page 114).

Tuberculins and Sera. The various details of tuberculin treatment have already been discussed in the general section on surgical tuberculosis. The method has been used with success in cervical tuberculosis, but there is this important local consideration that a long-continued tuberculin treatment results in such periglandular adhesions that subsequent operative interference becomes very difficult. We have therefore restricted its use to those cases in which operation was definitely contra-indicated.

Bereneck's tuberculin, autogenous tuberculin, and Moro's ointment have been the media which we have found most successful.

The value of the various sera has been already discussed.

Cervical Collars. The use of a cervical collar is an old-fashioned means of treatment, and yet it is one of considerable value. Based on the principle that rest aids the cure of tuberculosis, the patient is fitted with a poroplastic collar which, while it holds the head still, does not exert any deleterious pressure upon the glands. The collar is well padded with wool, and worn day and night. The degree of improvement which follows this simple treatment is remarkable.

Operative Treatment

The Scope of the Operation. Before the various indications for operations are discussed the scope of it must be decided on. Our view for a long period of time has been that only one type of operation is permissible in glandular tuberculosis, and that is a radical and complete excision of the affected group or groups of glands. We believe that the whole success of surgical treatment depends upon the thoroughness with which the operation is performed. We are utterly opposed to the method of incision and scraping: it does not pretend to eradicate the disease, it increases the risk of dissemination by destroying limiting barriers, and sooner or later it results in a secondary infection gaining entrance to the wound—in fact, it leads to each of the complications one is most anxious to avoid. It is this procedure of incomplete interference which has been responsible for the dissatisfaction with which the operation is associated in the minds of many.

Indications for Operation. There is one class of case in which we believe operative interference to be the only proper course, and, as this class forms the bulk of the early cases of cervical glandular disease in children, we can best express our views in the following summary:—

We believe that where children are concerned, 90 per cent. of cervical glandular tuberculosis is the result of a lymphatic spread from a local area of absorption.

That for a considerable time the disease remains limited to the gland or group of glands, and infection of the blood stream is a late complication.

That, in view of the fact that we possess no specific anti-bacterial agent

to overcome the tubercle bacillus, the wisest course is to remove completely the affected gland or group of glands before the disastrous complication of blood invasion or dissemination occurs

If the glandular condition fulfils the condition of being an example of the 'lymphatic' source of infection, the actual state of the gland is not of great consequence to us. We naturally desire it to be in as early a stage as possible, but the development of cold abscess formation makes no difference to the course which we follow

Contra indications to Operation

We do not advise operation —

- (1) If there is reason to believe that the glandular infection is a blood borne one
- (2) If the distribution of the glandular disease is haphazard and irregular, such a qualification being strongly suggestive of a blood infection
- (3) In the fibrous type of the disease
- (4) In cases which have been previously treated by incision and curetting
- (5) As a general rule, in the first year of life

In addition to these, which we look upon as absolute contra indications, we would make three qualifying statements —

We never undertake any operative interference during the stage of periadenitis. We advise instead that the gland be fomented with a saturated solution of magnesium sulphate until all signs of the periadenitis have disappeared

In the lymphoid type of glandular tuberculosis we recommend that, if operation is to be done, it shall be followed by a series of exposures to X ray therapy

If the child is suffering from a tuberculous toxæmia, we advise a short preliminary course of tuberculin prior to operation. We do so because our experience has been that immediate operation without this precaution is liable to be followed by a degree of shock quite out of proportion to the severity of the operation

Operation for Removal of Tuberculous Sub-maxillary Glands

The head is placed with a pillow below the nape of the neck and the face turned towards the opposite side. The incision begins in the middle line of the neck midway between the symphysis menti and the hyoid bone, extends downwards to the level of the hyoid, passes outwards across the neck to the anterior border of the sterno-mastoid muscle and upwards along the anterior border of the muscle to end opposite the angle of the jaw. The flap of skin thus outlined is dissected upwards until the body of the jaw is exposed. At the anterior border of the masseter muscle, the facial artery and vein are seen, and are divided at this point between ligatures. The reflection of the flap exposes the sub-maxillary salivary gland, and the lymphatic glands lying around it. The glands thus exposed may be

described as lying in a quadrilateral space, the body of the lower jaw forming the boundary above, while the anterior belly of the digastric lies in front, the posterior belly of the same muscle below; posteriorly the boundary is completed by the anterior border of the sterno-mastoid muscle, and at a deeper level by the stylo-maxillary ligament. Lying over the glands the facial vein is seen, and is ligatured and divided before it crosses the digastric muscle. The glands are separated from the structures which form the floor of the space, these being (from before backwards) the mylo-hyoid muscle, the hyo-glossus muscle, and the superior constrictor of the pharynx. The separation is carried out by passing the finger upwards on the deep surface of the glands. As this dissection is being completed, the facial artery is exposed as it crosses behind the digastric muscle to disappear beneath the glands.

The artery is divided between ligatures. The blood supply to the glands is now controlled, and the remaining dissection may be completed. The glands are dissected away from before backwards; a portion of gland tissue passes with the duct of the salivary gland beneath the posterior edge of the mylo-hyoid muscle; the duct is clamped and divided. As the glands are being dissected off the surface of the hyoglossus, care must be taken to avoid injury to the structures which lie upon it, more especially the hypoglossal nerve. When the removal is complete, the skin flap is restored to its position, and drainage is secured through a special opening made as a stab-wound at a level just above the wound.

Operation for Removal to Tuberculous Glands from the Anterior and Posterior Triangles. The position of the head is similar to that described in the previous operation except that the chin is tilted upwards so as completely to open up the side of the neck. The type of incision varies: the oblique incision extending from the tip of the mastoid process forwards and downwards has long been a favourite. Stiles recommends a 7-shaped incision when the disease is extensive and involves both triangles.

We generally employ an incision which passes across the neck almost transversely, so as to lie in a natural crease. This gives good access, while it leaves an unnoticeable scar. It extends from the anterior edge of the trapezius muscle to the middle line of the neck. The skin edges are reflected, a free separation being essential to a satisfactory operation. With the reflection of the skin certain structures appear; the sterno-mastoid muscle passes obliquely across the wound, behind it lies the posterior triangle uncovered to any extent by platysma except in the lower part, but probably occupied by enlarged glands if the disease is in any way extensive. Appearing at the middle of the posterior border of the muscle there are certain superficial nerves—the great auricular passing upwards towards the mastoid process, the transverse superficial cervical extending forwards across the neck, and the supra-clavicular nerves from the same super-

ficial origin coursing downwards towards the clavicle. Passing vertically down the side of the neck is the external jugular vein extending from the space between the angle of the jaw and mastoid process above to a point corresponding to the middle of the clavicle below. The vein is clamped in the lower part of the wound and separated upwards, as it approaches the upper end of the sterno mastoid it is surrounded by a small chain of superficial glands (the superficial cervical) and, as these are frequently the site of disease, they are removed with the vein. The glands are now removed from the anterior triangle. The platysma is reflected by a T shaped incision, the top of the T running along the anterior border of the sterno mastoid muscle, and the limb passing from the middle of this incision forwards to beneath the chin. The platysma is thus reflected in two flaps which can be replaced afterwards when the edges of the wound are restored. The division of the platysma exposes the enlarged glands. They may be said to lie in a muscular triangle bounded above by the posterior belly of the digastric, in front by the edge of the depressor muscles of the hyoid bone, and posteriorly by the anterior edge of the sterno mastoid muscle. The anterior edge of the sterno mastoid is defined and retracted. The definition is carried sufficiently deeply to expose the spinal accessory nerve accompanied by the superior sterno mastoid artery, a branch of the occipital, both passing obliquely downwards and backwards to enter the deep surface of the muscle. The glands are separated above from the sub-maxillary salivary gland and at a deeper level from the posterior belly of the digastric muscle. In front they are detached from the anterior belly of the omohyoid muscle and from the hyoid bone. The removal is completed by separating the glands from their deep relations, from the common facial vein, the middle and inferior constrictors with the thyro hyoid membrane, and more posteriorly the carotid sheath with the included vessels. It is exceptional to see such structures as the superior thyroid and lingual vessels, and therefore they have not been included in the description. The glands at their highest point lie in relation to the parotid gland, and a portion of this latter structure has frequently to be removed with the diseased glands.

The removal of glands from the posterior triangle is a simpler operation than the anterior dissection. With the separation of the skin the superficial nerves already mentioned are seen, but more important than the superficial nerves, one has to recognize the spinal accessory, which after it leaves the posterior border of the muscle becomes at first almost subcutaneous. The nerve is followed for some distance and cleared from the surrounding tissues. In removing the glands from the deeper relations of the posterior triangle the author begins by retracting the sterno mastoid muscle and separating the glands from the posterior margin of the sheath of the vein, this being done from the anterior border of the muscle. In this position the glands may be said to be divided into a small group above the spinal

accessory nerve and a larger chain below. When the separation from the vein sheath is complete, the sterno-mastoid is allowed to slip forwards and is held aside in that position. The glands are now dissected off the muscles which form the floor of the posterior triangle, the splenius capitis and the levator scapulæ. Care should be taken to remove portions of the glandular chain which pass between the two above-mentioned muscles. The separation of the glands on their deep surface completes the dissection. It is often unnecessary to retract the sterno-mastoid forwards. If the glands are small the dissection can easily be made from the front, but, if they are of any size, more room is obtained from the posterior route. In closing the skin wound, it is advisable to suture the platysma back into position with catgut; the observance of this detail prevents subsequent depression of the scar. The skin edges are brought together with clips or stitches, preferably the former, and drainage is established through a special stab-wound.

COMPLICATIONS DURING OPERATION

(1) *Abscess Formation.* The existence of a cold abscess does not materially affect the routine of the operation. If by chance it is opened, the pus will not produce a subsequent infection of the wound. The entire abscess wall should be removed with the deeper underlying glands, and if the abscess lies below the skin care is taken to prevent the incision passing through devitalized tissue; the skin wound is therefore planned to lie either above or below the abscess.

(2) *Injury to Vessels and Nerves.* The dangers of injury to the jugular vein have been overrated. If the opening in the vein is a small one it may be possible to repair it by a fine silk suture; it is not advisable to apply a lateral ligature, as there is the ever-present danger of its slipping. When the opening in the vein is large, it is better to proceed at once to ligature the vessel above and below the injured spot. It may be necessary to apply an additional ligature to the common facial vein as it enters the main vessel.

Injury to the spinal-accessory nerve may be unavoidable, as when there are masses of adherent glands, but in many cases it is the result of failure to recognize the nerve early in the dissection. When it is damaged an attempt should be made to suture it with fine silk thread.

If it is recognized that the glands are densely adherent to the carotid sheath, it is not advisable to persist in attempts at their separation. It is better to open the sheath low down in the neck, and, separating the vein from the associated structures, to divide it between two ligatures, taking care to avoid inclusion of the vagus nerve. The vein, with the adherent glands and the remains of the sheath, is dissected upwards. On reaching the junction of the common facial vein, the latter is divided between ligatures. The separation is continued upwards to beyond the limits of the disease, and at this point the vein is again secured and divided.

Recurrence. Nothing has brought operation into greater disrepute

than recurrence of the disease. A thorough removal of affected tissue is the best way to prevent this, but occasionally it happens in spite of every precaution. The parotid and the space between the adjacent edges of the splenius and the levator scapulæ are the common sites of recurrence. In the first instance it is difficult to see how the possibility of it can be avoided, as the glands are buried deep within its substance, but in the second a careful dissection is the best safeguard.

HODGKINS' DISEASE

Hodgkins' Disease—or lymphadenoma—is a glandular disease of great interest. It has all the attraction of the unknown, because we are still unaware of the conditions which originate it and of the means by which it may be corrected.

Its occurrence is less common in the child than in the adult, but, in view of the importance of the disease, we have decided to include a short description of its more important features.

ETIOLOGY

Our purpose will best be served if we review the more recent work which has been carried out in regard to the origin of the disease. The difficulty is to decide whether the glandular enlargement, which is such a characteristic feature, is a neoplastic condition or a granulomatous formation, the result of organismal infection.

In 1910 Fränkel and Much isolated a bacillus from the glandular tissue of a case of Hodgkins' disease. In character it was gram positive, granular, and non acidfast. They considered it to be a type of the tubercle bacillus. In 1913 De Negri and Micromet and Bunting and Yates, working independently, isolated in pure culture an organism which they considered identical with that described by Fränkel and Much. The investigations of this time indicated that the organism was a gram positive diphtheroid, showing club shaped involution forms and rods with branching filaments, the most successful culture media were Dorset egg medium and glycerine phosphate agar.

In 1915 Rhea and Falconer obtained what was apparently a similar organism by the inoculation of various media with portions of tissue from enlarged lymph glands in a case of Hodgkins' disease.

In the same year Fox reported the isolation of similar organisms in diseases distinct from Hodgkins' disease, and this finding has proved to be one of the obstacles in accepting the bacteriological explanation of the origin of the disease.

In view of Fox's results Bunting and Yates carried out a further investigation, and in the course of this they were able to isolate the organism, not only from Hodgkins' disease but also from the lymph glands of lympho sarcoma and chloroma, from cases of recurrent erythema with glandular enlargement, and from the spleen in Banti's

disease. Bunting explained his findings by supposing that there are diphtheroids of varied virulence with affinity for lymphoid tissue, including bone marrow and its products, and that the activities of different strains explained the various clinical and pathological pictures.

Longcope, who has published the most recent work on the subject, expresses the view that the bacteriological results are unsatisfactory. He believes that the relationship of the organism described above to Hodgkins' disease still remains unsettled.

One great obstacle to the study of the etiology of lymphadenoma has been the failure to transmit the disease by inoculation of infected tissue into animals. Bunting and Yates reported the results of the injection of pure cultures of the suspected diphtheroid bacillus into the axilla of the monkey (*Macacus Rhesus*). The glands of the neighbourhood became affected by a necrotic and suppurative process, but, if the animal survived long enough, the lymph node picture of Hodgkins' disease was seen. They reported that they were able to fulfil Koch's postulate in so far as they secured a pure culture from the original animal and reproduced the disease by injection of the culture into a second monkey. Rhea and Falconer repeated this experiment, but with negative results.

Olitsky attempted to obtain information regarding the organismal origin of the disease by testing the serum reaction. Using highly specific autogens capable of binding complement fixation antibodies, the results he obtained were entirely negative.

It is apparent therefore that, while some highly suggestive results have been obtained in favour of the organismal theory, there are discrepancies which make it impossible to accept this view without further proof.

The neoplastic theory is championed by Mallory and by Mueller. Mueller draws attention to the results of experiments carried out by Kopsch in 1919. The larva of the nematode (*Rhabditis pellio*) when given to frogs causes a local reaction in the mucosa of the stomach wall which histologically is found to be composed of eosinophiles, lymphocytes, and fibroblasts. The local reaction destroys the larvæ, but if the latter exists in such an amount that the metabolic product from their destruction circulates in the tissues, there is a stimulation of connective tissue and other cells, which results in a change suggestive of tumour formation. Mueller argues that the cells in the lymph nodes in Hodgkins' disease are stimulated to proliferate in this way. In his article he sums up the points in favour of the neoplastic theory as follows :—

1. There is tumour formation with little tendency to necrosis.
2. Invasion and destruction of adjacent structures may occur.
3. Metastasis occurs in such distant organs as spleen, bones, skin, and dura, the deposits showing characteristics of the primary focus.
4. The recognition of cases which are on the border line between

lymphosarcoma and Hodgkins' disease, the two diseases appearing together in different regions in the same subject

Bunting and Yates remain convinced of the truth of the infection theory, and in favour of the disease being of bacterial origin they quote the following points —

- 1 The temperature which is present in certain stages of Hodgkins disease, but in no known type of neoplasm
- 2 The characteristic blood picture suggesting a toxic affection of the blood forming organs
- 3 The occurrence of the disease in connection with carious teeth in which the characteristic diphtheroid organism has been found
- 4 The increase of fibrous tissue elements in the glands as the disease progresses
- 5 The cure in a certain percentage of cases when treated on the assumption that the disease is bacterial

PATHOLOGY

The affected glands show a characteristic picture. They are enlarged on section they are fleshy and of a greyish yellow colour, each gland is discrete, and the capsule is free from peradenitis

Microscopically the most striking feature is the presence of phagocytic giant cells arising from the endothelium of the lymph spaces. Some of the cells are mononuclear, some are multinuclear, occasionally large syncytial masses are formed. Coincident with this phase there is an increase in the lymphoid tissue of the gland, but this change soon gives place to a proliferation and subsequent fibrosis of the reticulum. In some instances there is an increase in the number of eosinophilic cells in the substance of the gland. The gland ultimately becomes fibrosed. An increase of lymphoid tissue also occurs in the malpighian corpuscles of the spleen (hard baked spleen) and in the liver, kidneys, testes, and bone marrow. The blood undergoes changes in the later stages of the disease there is a secondary anaemia, a high relative percentage of neutrophils, an increase in the size and number of the platelets, and an emigration of megakaryocytes

CLINICAL FEATURES

It has been noted that the disease is more prevalent in boys than in girls, and this has been our experience. The children have been small boys of an average age of four to six years. The glands which first become enlarged are usually those of the neck, and the subsequent history is one of rapid growth. Beginning in the upper carotid group, the characteristic enlargement spreads downwards into the supra clavicular groups, and thence into the mediastinum. The feature of retrogression and advance which is so characteristic of the adult cases is not met with in children to the same

extent. Beside the glandular enlargement there are the usual symptoms of secondary anæmia. If the glands are enlarging rapidly, there may be an irregular pyrexia. Attention has lately been paid to various cutaneous signs which are said to be characteristic of the



FIG. 357.—Hodgkins' Disease (Lymphadenoma).

Mass of cervical glands removed from boy 5 years old (Fig. 358). The picture illustrates the discrete character and the comparatively large size of the affected glands

disease—erythematous points or macules, prurigo and pruritus, small tumours and skin nodules showing a histology similar to that of the glandular change, the occurrence of a protein in the urine which resembles, but is distinct from, the Bence-Jones' protein found in 'myelomatosis.'

As the glandular enlargement extends, various pressure effects

are seen. The disease progresses rapidly to a fatal issue, the majority of children affected succumbing within a year.

DIAGNOSIS

Hodgkins' disease requires to be distinguished from tuberculosis, leucothæmia and lymphosarcoma, if this is impossible from the clinical features, one of the glands should be removed for microscopical examination.

TREATMENT

The treatment may be summarized as follows —

- 1 Remove any source of infection which is in proximity to the diseased area—the teeth, tonsils, etc., should be investigated from this point of view.
- 2 Excise the glandular disease in the early stage.
- 3 Arrange for long continued application of X rays to the affected part. This must be continued at intervals after the glandular swelling has subsided.
- 4 Administer arsenic in suitable doses, sodium cacodylate is the preparation which has given most satisfaction.
- 5 Improve the general hygiene surroundings.



FIG. 358.—Hodgkins Disease (Lymphadenoma) (Boy 5 years old)

THE MID LINE OF THE NECK

DEVELOPMENTAL FACTS OF CLINICAL SIGNIFICANCE

The position and nature of the various branchial clefts and arches upon the side of the neck have been already described.

The Thyroglossal Duct and the Thyroid Gland. In the human embryo of six weeks' development, between the second, third, fourth, and fifth branchial arches on each side and between the inferior maxilla and the base of the heart there is a triangular space which is called '*the mesobranchial field of His*'. Within this area, in front of the second cleft, a median invagination of the wall of the pharynx appears, and forms a depression, which gradually deepens until it becomes a sac, the orifice of which opens on the summit of the tuberculous impar (foramen cæcum). The posterior part of this pouch becomes bilobed and travels caudally, and the tissue intervening between the orifice and the bilobed caudal extremity becomes the thyroglossal duct. Towards the latter half of the second month the

developing hyoid bone divides the thyroglossal duct into two portions, a superior (cephalic) and an inferior (caudal), the superior or lingual portion extending from the foramen cæcum of the tongue to the hyoid bone, the inferior or thyroid portion from the hyoid bone to the isthmus of the thyroid gland. The line of the thyroglossal duct is from the foramen cæcum of the tongue, through the posterior part of that organ following the lingual raphe, in front of, through, or behind the hyoid bone, being intimately connected with the periosteum and the thyro-hyoid membrane, and along the anterior surface of the trachea to the isthmus. The thyroglossal duct soon atrophies, but its bilobed caudal end proliferates into the glandular structure which later becomes the isthmus of thyroid gland. The last stage in development is the severance of connection between the developing thyroid gland and the underlying pharynx, and in an embryo eight millimetres long the separation is complete (Broman). The thyroglossal duct is originally lined with a single layer of cylindrical and occasionally ciliated epithelium.

In the normal human embryo the duct begins to atrophy during the fifth week, and by the end of the eighth week it has disappeared, leaving an evidence of its presence in the foramen cæcum of the tongue. Exceptionally it happens that the duct remains permeable in its course, and when this is the case islets of glandular tissue may remain free, from which accessory thyroids develop.

The *thyroid gland* has at first a cylindrical structure, but lumina appear, the outline becomes beaded, and the structure becomes broken up into rudimentary follicles. Later on, the epithelium loses its cylindrical character, cellular desquamation occurs so as to fill the lumen of the alveoli, and at the end of intra-uterine life, the thyroid is composed of a uniform, undifferentiated mass of cells. A few weeks after birth, regeneration of the thyroid takes place: the epithelium shapes itself into epithelial cords, which, undergoing a process of direct division, form new alveoli in which the epithelium is cubical or flat.

Thymus-parathyroid

From the dorsal part of the third branchial pouch the third epithelial body arises, and from the ventral portion, the greater part of the thymus is developed. The third epithelial body is the forerunner of that parathyroid which is most closely incorporated with the thyroid gland, and from its developmental association with the thymus gland it descends with that organ to reach its eventual site in the vicinity of the lateral lobe of the thyroid.

The fourth and fifth pouches give rise to the remaining parathyroid, to a thymic rudiment, and to a structure known as the post-branchial body. This last was at one time supposed to take some part in the development of the thyroid gland, but this view has been disproved; it is probably a separate organ, the significance of which is not clear; it probably atrophies and disappears.

DEVELOPMENTAL ERRORS

A Minor Errors

A variety of errors of minor surgical importance may appear in mesobranchial development—they include such rarities as —

- 1 The inclusion of thymic nodules within the thyroid gland from persistence of the fourth branchial body
- 2 The inclusion of the fourth parathyroid within the thyroid
- 3 Congenital absence of the thyroid gland in whole or in part, or its replacement by a cystic mass
- 4 Ectopia thyroidis from arrest of the caudal migration of the thyroid
- 5 Accessory thyroids from the errant growth of primary thyroid tubules, usually in the line of the thyroglossal duct or more rarely in regions remote from the duct

The errors are usually discovered by chance, and it is only when they are the sites of derangement or of tumour formation that they become of surgical significance

B Errors associated with the Thyroglossal Duct

The development of a *lingual thyroid* and the occurrence of *thyroglossal cysts* and *fistula* are the most important errors under this heading

Lingual Thyroid We have twice seen examples of this condition in children. The error is brought to the notice of the surgeon because the child suffers from attacks of dyspnoea. The common causes are excluded, and, in the course of the routine examination of the mouth and throat, it is discovered that there is a tumour like projection in relation to the posterior third of the tongue. The tumour is embedded in the substance of the tongue, but projecting on the surface immediately in front of the epiglottis, its consistency being firm and its outline rounded. The dyspnoea which it induces is the result of pressure upon the epiglottis and temporary closure of the upper aperture of the larynx. The lingual tumour is found to consist of normal thyroid tissue, and may exist in company with a normally placed thyroid, in which case it is grouped as an example of an accessory thyroid, or it may be an example of a true ectopia thyroidis, in which case the normal thyroid is absent. The influence of this distinction upon subsequent treatment is apparent, but it is difficult to know how the distinction is to be made. Palpation of the lower reaches of the neck may afford suspicions that the normal thyroid is absent, but in most cases it is only when symptoms of hypothyroidism develop secondary to removal of this tumour that the exact state of affairs is appreciated, and one realizes that the lingual thyroid has been an example of an ectopia thyroidis.

DIAGNOSIS The posterior third of the tongue is affected in child

hood by angiomatous tumours, by lymphangiomata, and by dermoid cysts. These conditions have to be excluded when the diagnosis of a lingual thyroid is entertained.

TREATMENT. If the condition is not inducing urgent symptoms, it is wise to leave it alone. The operation for removal of the tumour is associated with considerable risk, and there is the possibility that its removal may be followed by symptoms of hypothyroidism.

If treatment is a matter of urgency, the tumour must be removed. This may be done through the mouth, but it is safer to approach the site of the disease through a supra-hyoid or a sub-hyoid pharyngotomy. The child must be kept under observation for some time after the operation, and any evidence suggestive of hypothyroidism is treated appropriately.

Thyroglossal Cysts and Fistulæ. As has been already mentioned, the thyroglossal duct should disappear at an early stage of foetal life. Unobliterated portions, however, may persist, especially in the region of the hyoid bone, and so may lead to the formation of cysts. Cysts which develop in this way above the level of the hyoid bone are sometimes termed *lingual dermoids*, while those which appear below the hyoid bone are called *infra-hyoid cysts*.

CLINICAL FEATURES. The swelling of the cyst is usually apparent at some period in the first ten years of life. There are long intervals of time when the enlargement appears to be a stationary one, and there are periods when the growth is progressive. Incidental infection of the cyst sometimes occurs.

If the cyst is opened under a misapprehension as to its real character, or if it becomes infected and bursts, the discharge continues and an intermittent fistula is established. Sub-hyoid cysts have no clinical features of importance beyond the actual swelling; supra-hyoid cysts (lingual dermoids) from their position may project into the mouth behind the tongue, and if their bulk is considerable they may produce obstructive symptoms in swallowing or in breathing.

PATHOLOGY. The cysts are lined with columnar-celled or squamous-celled epithelium: ciliated epithelium may occur in sub-hyoid cysts. The cyst wall is composed of dense fibrous tissue, and the contents are usually of a creamy pultaceous character, the result of desquamation of the lining epithelium. From the upper edge of the cyst a fibrous band extends upwards; this is the remnant of the thyroglossal tract, and its relationship to the hyoid bone should be carefully noted, for upon this observation a detail of operative treatment will depend.

DIAGNOSIS. There is a variety of conditions which may simulate a thyroglossal cyst. The sebaceous cyst and the lipoma are recognized by their close relationship to the skin, and by the fact that they do not participate in deglutition movement because they are not fastened to the anterior surface of the trachea. Diseased lymphatic glands, and especially glandular disease which has softened, may be mis-

taken for the developmental error. The similarity is increased by the tendency which glands have to become adherent to the anterior surface of the trachea, but a careful clinical investigation will usually make the distinction clear. A distinctive feature of the supra-hyoid cyst is its tendency to project upward into the mouth.

TREATMENT Complete removal of the cyst and the associated thyroglossal tract, if such exists, is the only satisfactory treatment. Incision is harmful, because a sinus persists, and the inevitable entrance of infection makes subsequent removal more difficult.

A vertical incision in the mid line of the neck gives the necessary access, the cyst is dissected free and removed, the related tract is followed upwards, and if it lies in contact with the hyoid bone, a central block of the latter is removed. Above this limit the tract is traced among the muscles of the tongue until the neighbourhood of the foramen cæcum is reached, the tract is then ligatured, and the attached stump is treated with pure carbolic or with the actual cautery.

If the cyst removed is a large supra hyoid one care is required in the immediate after treatment, because of the tendency which there is for dyspnoea to develop.

Thyroglossal Fistulæ Two varieties of thyroglossal fistulæ are recognized—the *primary* or *true fistula*, the result of the spontaneous communication of an underlying thyroglossal duct with the skin surface, and the *secondary fistula*, which has developed as the result of incision of a thyroglossal cyst (a *thyroglossal sinus* is the more correct term to apply to the latter condition).

The opening is a small one, and occurs at some point in the mid-line of the neck between the hyoid bone and the top of the sternum, the common situation being immediately below the level of the cricoid cartilage. It causes little inconvenience except for the mucous discharge which appears intermittently, occasionally a vertical ridge indicating the presence of a persistent thyroglossal duct, is visible above the opening. The duct is lined with a columnar epithelium, which is sometimes ciliated, and tissue resembling atrophied thyroid tissue may be found in the duct wall.



FIG. 359.—Thyroglossal Fistula (Girl 10 years old)

TREATMENT. The fistulous opening is included in a median vertical incision, and through this the underlying tract is exposed. A complete removal is necessary to prevent recurrence of symptoms.

SURGICAL AFFECTIONS OF THE THYROID GLAND

GENERAL CONSIDERATIONS

The process of development by which the thyroid gland is formed has been described. At birth the gland structure is more cellular than it is in later life, and there is therefore less space for the accumulation of colloid material, the gland secretion being comparatively scanty, and the proportion of iodine which it contains being relatively small. These various peculiarities may be taken as indicating that in the early months of life, the endocrine function of the thyroid is reinforced from extrinsic sources: the natural mother's milk is the medium through which this assistance is best obtained, cow's milk being less valuable. The thyroid health of the mother has a powerful effect upon the growth and function of the thyroid of the child, and the practical bearing of this observation is important, because, if there is reason to suspect the efficiency of the mother's thyroid, glandular therapy in some form should be arranged for.

During the cycle of childhood the gland undergoes incidental periods of activity similar to those met with in adult life: birth and puberty are the periods at which enlargement occurs.

SURGICAL CONSIDERATIONS

During the period of childhood, various pathological changes may occur which are conveniently grouped as follows:—

- I Inflammatory processes { Acute thyroiditis
Tuberculous thyroiditis.
- II Goitre of various varieties.
- III. Tumours (Teratomata and sarcomata).
- IV. Deficiency diseases of the gland (Cretinism and myxœdema).

I. Inflammatory Processes

Acute Thyroiditis. During the progress of the acute infective diseases it sometimes happens that the thyroid gland becomes the site of a local inflammatory reaction. The infection is usually a streptococcal one, and is carried to the gland by way of the blood stream. While acute signs of the disease are rare, slight manifestations are probably not uncommon, but they are masked by the more acute general symptoms. In a characteristic case, the gland becomes enlarged and tender, there is difficulty in swallowing and in breathing, and the child affects a characteristic attitude, holding the head forward and the neck outstretched. Owing to the specialized nature

of the thyroid tissue, resistance to the infection is deficient, and abscess formation readily occurs

DIAGNOSIS The possibility of acute thyroiditis being responsible for dyspnoea should be kept in mind, especially if the dyspnoea develops in the course of a general acute illness

Locally the condition is simulated by acute lymphadenitis of the lower cervical glands, and in distinguishing between the two processes help is obtained by observing the presence or absence of deglutition movement

RESULTS The disease has two serious aspects. It may prove fatal by inducing an œdema of the underlying air passages, or at a later period the destruction of the gland from the septic process may result in thyroid deficiency

TREATMENT In the early stages of the disease hot fomentations are applied, and if it is apparent that this is not affording sufficient relief, an incision is made over each lateral lobe. The incision should be in a vertical direction, and of such a depth as to penetrate the capsule of the gland. If suppuration develops, early incision and drainage will localize the infection and to some extent may minimize the destruction of the gland

Tuberculous Thyroiditis A single example of this rare disease has come under our observation. It was manifest in a girl ten years of age, the subject of generalized tuberculosis. A cold abscess developed over the right lateral lobe of the thyroid, and a subsequent operation showed that there were a number of tuberculous nodules scattered throughout the right half of the gland. Beyond the local change, no clinical manifestations were apparent

The abscess cavity was incised and curetted, and a local cure followed, but on the repetition of similar conditions we would probably excise the segment of affected gland

II Goitre

In children pathological enlargement of the thyroid gland is found under three conditions —

- A Congenital goitre
- B The acquired goitre of infancy and childhood
- C Exophthalmic goitre

A Congenital Goitre Systematic examination of the necks of all newborn children would reveal an unexpectedly large percentage of this derangement

ETIOLOGY The etiology is closely related to the occurrence of parental goitre. Crotti observed seven cases, in each of which the mother was goitrous, Rubsammen reported nine cases with a similar connection. It is not stated what was the pathological nature of the maternal goitre, but it would seem reasonable to suppose that the influence was to diminish the endocrine supply to the foetus, with the

result that the foetal gland enlarged in its attempt to supply the deficiency.

PATHOLOGY. As far as we are aware, every case of congenital goitre has been an example of the parenchymatous type; colloid and cystic varieties have been recorded, but they are extremely rare. Cases have been described in which the vascularity of the gland has



FIG. 360.—Thyroid Gland (Girl 10 years).
Tuberculous disease of the thyroid gland.

been unusually great, but mechanical influences may have produced this effect.

The volume of the tumour is variable—it seldom exceeds that of a hen's egg. As a rule, it is cervical in position, though one or two examples of thoracic goitre have been described. Histologically the congenital goitre is similar in structure to the adult parenchymatous (colloid) form.

Congenital goitres have considerable obstetrical interest, if their size is considerable. Situated between the chin and the sternum they may prevent flexion of the head during the passage of the foetus and thus cause face presentation.

The goitre occasionally assumes a circular form, passing behind the oesophagus, so as to exert an embracing effect upon the trachea and cause fatal dyspnoea.

CLINICAL FEATURES Many examples of congenital goitre remain latent as far as clinical symptoms are concerned, and eventually subside with or without treatment, in other instances the goitre continues to grow after birth until it attains a large size. It disturbs the patient by its actual bulk, it causes dyspnoea and dysphagia, and it may prevent the baby from nursing properly. The swelling may be responsible also for the condition known as 'asthma neonatorum'.

A small group of congenital goitres are classed as *fulminating* from the intense character of the features which they induce. The child may be born dead or, if not, complications appear soon after birth, and develop with alarming rapidity. There is intense cyanosis, dyspnoea, and stupor, the mouth and trachea are filled with mucus, there is a hoarse rasping cry, the eyes protrude, and death quickly follows if relief is not obtained.

DIAGNOSIS The average case of congenital goitre is easily recognized, but difficulty may arise in connection with the larger varieties, for they are simulated by swellings which resemble goitre but which are really tumour formations of the thyroid, more especially the teratomata and sarcomata.

TREATMENT To some extent the treatment of congenital goitre is a prophylactic problem, the treatment of a goitrous mother by the ordinary methods of thyroid therapy during the course of her pregnancy may prevent the development of congenital goitre in her offspring. If the goitre is of the *fulminating* variety, in so far as obstructive symptoms appear soon after birth, immediate relief treatment is demanded. Ice applied to the neck may diminish the bulk of the tumour, the mouth and throat are cleared of mucus, and the tongue is pulled well out. When the goitre is incarcerated in the upper aperture of the throat it may be liberated from this position by manipulation with the fingers. If simple measures fail there should be no hesitation in exposing the thyroid, and in liberating or resecting a portion of it. Tracheotomy is rarely successful. Apart from such emergency methods, the later treatment of the case is along medical lines. Iodine is administered as an ointment over the affected region, and thyroid extract is given by the mouth.



FIG. 301.—Parenchymatous Goitre
(Child 3 years old)

B The acquired Goitre of Infancy and Childhood The development of goitre in children is not uncommon in regions where goitre is endemic. As in adults, all varieties of the swelling are found,

but the parenchymatous form is the most frequent. The majority of cases show evidence of toxicity, the basal metabolic rate is raised, there is a general physical deterioration, the child is below the normal standard of health and development, has a frail appearance, and is easily fatigued. The toxic symptoms rarely show the acute phases which are so common in adult cases.

So far as treatment is concerned, the same rules apply as are followed in adults. Operative interference is indicated if the enlargement is cystic in character.

C. Exophthalmic Goitre in Children. Exophthalmic goitre is rare in early childhood, but cases are occasionally met with in older children. The influence of fright in originating the symptoms has been repeatedly discussed, and in this connection it is interesting to recollect that a number of cases of exophthalmic goitre in children were described as occurring after the Zeppelin raids of the recent war (Thomson).

The clinical features are similar to those of adults, but consistently less in degree. The exophthalmos is slight, but the thyroid enlargement and the cardiac derangements are considerable.

The prognosis is better in the child than in the adult, the majority quickly subsiding under medical treatment. Simple rest and quietness with careful dieting and the occasional administration of a cardiac tonic are indicated. We have been unable to trace any case in the literature in which surgical interference was resorted to.

III. Tumours of the Thyroid Gland

Various tumour formations may appear in the thyroid gland during the period of childhood; they may be grouped as follows:—

Fœtal adenomata.

Connective tissue tumours (sarcomata, endotheliomata, and peritheliomata).

Mixed tumours.

Dermoids

Teratomata.

Fœtal Adenomata. The fœtal adenoma develops in the early years of life, but the child is usually over ten years of age before the condition is recognizable clinically.

Several small rounded mobile and painless nodules are detected throughout the substance of the gland, and their collective presence or the size of an individual one may give rise to a goitrous appearance. The tumour is symptomless at this stage, but its relationship to the toxic adenomata of later life has to be borne in mind. The adenoma is formed of embryonic tissue arranged in groups of cells and follicles.

The follicles are small, and the cells which line their walls have a fœtal character; the alveoli in the early stages do not contain colloid, though they may do so later. The inter-follicular connective tissue is very abundant, and sometimes presents a mucoid appearance.

Fœtal adenomata demand surgical interference if they become of such a size as to constitute a goitre, for conservative methods of treatment have no apparent effect upon them. Should surgical interference become necessary it should take the form of enucleation of the tumour if it is single and of appreciable size, or of removal of the affected segment of the thyroid.

Connective Tissue Tumours *Sarcoma* Sarcoma of the thyroid gland sometimes occurs in early life, and the tumour grows with extreme rapidity. In the early stage it is mobile and sharply defined, but soon becomes adherent to the surrounding tissue, it then becomes diffuse in outline, and its mobility is lost. This gives rise to pressure symptoms and to pain. The tumour is soft in consistency, somewhat friable, with a greyish white surface when cut. The blood supply is increased and the tumour has a tendency to undergo necrosis, fatty degeneration or calcification. Microscopically any of the different varieties of sarcoma may be recognized, but the fibro sarcoma is the most common type.

The tumour is only suitable for operation in its early stages. In its later phases, treatment by X ray or radium may result in diminution of the bulk of the swelling.

Endothelioma and Perithelioma are at first sharply defined tumours limited by a fibrous capsule, but when the latter becomes invaded the tumour is diffuse in outline. The endothelioma of the child is an exceptionally vascular tumour, an irregularly disposed connective tissue forming a framework in which large vascular lacunæ are found, containing fluid or coagulated blood. The cells lining the capillaries proliferate and desquamate until they completely fill the vascular clefts, thus forming solid cellular cords and nests. 'Russell's corpuscles' are frequently found scattered throughout the tumour, and metastases, which have the same characters as the primary tumour, take place through the blood-vessels.

The perithelioma has been described in the thyroid of the child. Microscopically the appearance somewhat resembles that of the plexiform angioma. Around the lumen of the capillary there are multiple layers of cells forming a thick mantle to the blood-vessel, the proper endothelium being also proliferated. The tumour is a circumscribed one, forming a rounded and firm nodule in the thyroid substance. Macroscopically it is of a greyish white appearance with a well defined capsule.

Both the endothelioma and the perithelioma are suitable for local excision if they are recognized at an early stage.

Mixed Tumours These tumours are characterized by their polymorphic aspect, they contain connective and epithelial tissue, cartilage and lime, they are akin to teratomata, but, unlike the latter, they do not contain any well differentiated organ. Being congenital in origin, the tumour may be recognized in childhood as a smooth, nodular growth of variable size, firm or hard in consistency.

Histologically, osseous and cartilaginous tissues are diffusely mixed with thyroid elements.

Dermoids and Teratomata. Tumours of these types are exceedingly rare, only three or four cases having been reported in the literature. They represent a further step in the development of mixed tumours, for, while the latter are composed of unorganized elements, in dermoids and teratomata the elements are organized into rudimentary tissues, such as hair, skin, etc.

IV. Deficiency Diseases of the Thyroid Gland

(Cretinism and Myxœdema)

Cretinism is the clinical disorder which arises from either a congenital absence or a pre-natal destruction of the thyroid gland. The origin is uncertain, but it is presumed that it is due to a maternal poison acting on the developing thyroid of the foetus.

Myxœdema is the result of a thyroid deficiency which has been acquired after birth—infections of the thyroid gland may be responsible for it, or it may follow removal of an ectopia thyroidis, as in a lingual thyroid.

There are two surgical aspects of these deficiency diseases which are important. The first is the danger of submitting the subject of hypothyroidism in any form to surgical interference: they stand operation exceedingly badly, and surgical manipulation under anaesthesia is inadvisable until suitable thyroid treatment has been undergone. The second surgical aspect is in connection with the possibility of relief to symptoms by thyroid grafting. Many attempts have been made to obviate the necessity for thyroid feeding by implantation of healthy gland, but up to the present the results have been unsatisfactory. It is possible that by paying closer attention to the question of blood compatibility between recipient and donor the future of the operation may be more successful. Recent investigations have shown that in the bone marrow we have the most suitable medium for the implantation of a thyroid graft.

THE THYMUS GLAND

The thymus gland is an organ of great importance in the surgical history of childhood. The maximum point of its development is reached in the early years of life, and whatever function or functions it possesses are probably exercised during pre-natal life and the year which immediately succeeds birth; none the less, its possible influence has constantly to be considered in the surgical procedures of childhood, especially in those which entail the administration of a general anaesthetic.

SURGICAL ANATOMY

It is correct to describe the thymus as existing at birth in two portions—a cervical portion which passes through the upper aperture of

the thorax into the root of the neck, and a thoracic portion which is the main bulk of the gland. At birth it is a soft greyish white organ, spongy in texture, and roughly pyramidal in shape. Its surfaces may be described as antero-posterior, right and left lateral, its apex may come into contact with the thyroid gland, and it is always indirectly connected with it through the medium of the thyro-thymic ligament and branches of the inferior thyroid artery, its base extends downwards over the heart to the level of the fourth intercostal space. The organ lies in intimate relation to many vital structures—the cervical portion, sometimes spoken of as *the surgical portion*, comes into contact in front with the sterno-hyoid and sterno-thyroid muscles, and posteriorly with the œsophagus and the inferior laryngeal nerve. The relations of the thoracic portion are not of surgical significance. The organ is provided with a delicate fibrous capsule, and from the deeper surface of the covering, septa extend inwards so as to subdivide the gland into lobes.

The blood supply has a wide source but comparatively small ramifications, the thyroid arteries, the internal mammary, the innominate, and the intercostal vessels contributing the supply. The gland has an intimate lymphatic supply, and a portion of it is peculiar because it opens directly into the venous system without passing through lymphatic glands. This peculiarity has an important bearing upon tumour formation within the gland and the resulting dissemination.

The nerve supply is of sympathetic origin, and it is possible that there is a contribution from the vagus nerve.

Histology and Histogenesis. The thymus is divided into two portions—the *cortical* and the *medullary*. Throughout the entire gland there is a framework or reticulum carrying the blood and lymphatic vessels, which is formed by a process of ramifying tissue, circumscribing spaces containing cells of various kinds. The reticulum of the cortex is fine and abundant, the cells small and possessing long filamentous prolongations, while the reticulum of the medulla is composed of relatively large ramifying cells. The spaces between the reticula are occupied by numbers of small dark cells resembling small lymphocytes (thymic lymphocytes), which show great variety in size, many of them being in active mitosis. Besides the thymic lymphocytes, neutrophile and eosinophile leucocytes, plasma cells and mast cells are present. The eosinophiles are peculiarly abundant during the period from the seventh month of fetal life up to a few months after birth. The medullary substance resembles the cortical substance in general arrangement, but is distinguished by the presence of Russel's corpuscles, irregular epithelial cells, and giant cells.

Embryology. The thymus anlage is derived from the proliferation of the ventral portion of the third and fourth branchial clefts. At first there is an intimate connection between the thymus and the parathyroid III anlage, developed from the dorsal portion of the third and fourth clefts, but this is lost early, though its influence is seen in

the frequency with which thymus nodules are found in the lower pole of the thyroid gland. The thymus anlage is at first connected with the pharynx by the thymo-pharyngeal duct, but this disappears and the anlage thus becomes free, except at its cephalic extremity, where a thin elongated portion persists. In later life this portion becomes the upper pole of the thymus (cervical), while the lower portion of the anlage proliferates to become the intra-thoracic thymus gland.

Physiology. It was formerly thought that the thymus grew until the end of the second year after birth, and that from this time it progressively atrophied until it disappeared more or less entirely after the thirteenth year. To-day it is generally accepted that the thymus is an organ specially related to the period of growth, and that as soon as physical development has reached maturity the necessity for the organ appears to cease, and it therefore atrophies, the retrogression being known as a physiological involution. Waldeyer has pointed out, however, that there is no such thing as complete disappearance of the gland, for even in subjects of sixty to eighty years of age he found remains of thymic tissue, and he was able to demonstrate that, in such cases, cell mitosis persisted, and that the regenerating power of the parenchyma was still present. In fact, the correct appreciation of the life of the thymus is that it increases in weight up to the time of puberty, that during this time it reaches its maximum of development, and that it then begins to undergo a physiological involution, but never disappears entirely during life.

The Physiology of the Thymus Gland and related experimental Work on its Functions. While it is certain that the thymus fulfils a purpose at some period in its life history, the elucidation of its function has proved a matter of extreme difficulty, and at the present time the problem remains unsolved. Many physiologists proclaim it as a hæmopoietic organ, but even on this point the evidence is not clear. The participation of the thymus in the production of red-blood corpuscles is doubtful: that it is capable of producing lymphocytes seems to be probable, that it participates in the production of eosinophiles and other leucocytes is unlikely.

Does the organ produce any internal secretion? The answer is that none has yet been isolated, though there is considerable circumstantial evidence of its existence. The effects of thymectomy have been studied by many observers, and the results are curiously contradictory. Thus, in 1912 the experimental work of Klose and Vogt indicated that the thymus was intimately related to the process of calcium metabolism, and that its removal was followed by muscular weakness, osseous disturbance, changes in the central nervous system, and general nutritional errors. On the other hand, in 1919 Park and McClure published a large monograph dealing with seventy-five thymectomies, and their results were entirely negative, with the exception that thymectomy might delay closure of the epiphyses.

Feeding, injecting and grafting experiments have been equally

contradictory it has been suggested that thymic extract has an influence upon metabolism, that it is responsible for the production of tetany, and that it has a stimulating effect upon the conductivity of nerves, but the evidence in support of these various views is unconvincing, and a great deal of investigation is still demanded.

The question has been repeatedly raised of the interdependence between the thymus and the recognized organs of internal secretion, and some evidence has been established as to the interdependence of the thymus, the thyroid, and the gonads, but its relationship to the other glands of internal secretion has not been clearly demonstrated.

THE SURGERY OF THE THYMUS

There are a number of morbid conditions of the thymus gland which either have a direct surgical significance or which are indirectly related to other surgical diseases. Regarded from this standpoint the following conditions may be considered —

- I Congenital absence or hypoplasia
- II Acquired pathological involution
- III Pathological enlargements
 - Acute oedema
 - Hæmorrhage and hæmorrhagic cysts
 - Acute thymitis (secondary)
 - Thymic tumours
 - Thymic hyperplasia or status thymolympbaticus

The surgical significance of many of these conditions may be dismissed in a few words.

I Congenital Absence or Hypoplasia

The importance of this condition lies in the fact that it appears to have an influence upon mental disturbance in children. Thus, in twenty eight mentally defective children, Bournville found the thymus absent, and, basing his conclusions upon a large number of autopsies of mentally defective children, he found the thymus absent in 70 per cent of the cases. The observations of Sajous and Harrower support Bournville's contentions. The position thereby raised is a suggestive one, for it may mean that thymus grafting would be beneficial, and experimentalists have shown that thymus implantation is readily secured.

II Acquired Pathological Involution

Pathological involution must be distinguished from the normal and physiological involution which has been already discussed. Its only surgical importance lies in the fact that the atrophy is coincident with chronic septic diseases such as empyema, and it would seem that a septic intoxication is responsible for the change. No event of clinical significance is attributable to the atrophy.

III. Pathological Enlargements

Thymic enlargements are conditions of extreme surgical importance; they readily induce pressure effects of a serious nature, while the thymic hyperplasia (the status thymo-lymphaticus) is recognized as one of the most dangerous morbid conditions of childhood.

(a) **Acute Œdema.** Children who suffer from an inflammation within the chest wall are liable to phases of acute thymic congestion, and these are accompanied by œdema. In acute empyema, for example, the process occurs, and it is one of the causes of sudden death in the disease. An item of importance to the practical surgeon is the danger which exists of inducing acute thymic œdema by the introduction of large sub-pectoral infusions of saline in infants.

(b) **Hæmorrhage and Hæmorrhagic Cysts.** The newborn child is liable to the development of hæmorrhage within the thymus, manipulation during birth being most probably the exciting factor. In older children thymic hæmorrhages occur in association with septicæmia and hæmophilia. The accident is followed by the immediate danger of thymic pressure, but it is also the source of a later development which may have surgical significance, the appearance of hæmorrhagic cysts throughout the gland; these may attain considerable size, and so exert harmful pressure effects.

(c) **Acute Thymitis.** A primary acute thymitis has not been observed, but secondary thymitis (a metastatic development) has been reported on several occasions. Abscess formation is the usual sequel, as the thymus appears to possess little resistant power to pyogenic infection. In rare instances, the thymus is the site of tuberculous disease and of gummata.

(d) **Tumours of the Thymus.** Primary tumours of the thymus are more frequent than is usually supposed. The simple tumours—fibromata, myxomata, and cysts of various kinds—are rare, but malignant tumours and more especially the sarcomata are occasionally met with. The tumours originate from the connective tissue of the gland, and the lymphoid cells of the cortical substance are also capable of giving rise to sarcomata (the lymphosarcomata or thymomata). There are some thymic tumours which represent such a variety of structural forms that Ewing suggests 'that they are varieties of infective granulomata, or, at best, particular forms of cell growth on the basis of the infection granuloma'. Carcinomatous affections of the thymus are unknown in childhood.

CLINICAL FEATURES The clinical features associated with thymus tumours are of a most distressing character. For a time the tumours grow slowly, and symptoms are absent except that there may be difficulty in breathing if the head is extended, but, after a certain stage in the growth of the tumour is reached, congestive changes are produced which so rapidly increase the bulk of the thymus tumour that symptoms develop with alarming rapidity. There are three main features

—dyspnoea of increasing severity, cyanosis and œdema of the head and neck, and turgescence of the superficial veins above the level of the obstruction. A type of vicious circle is actually in process, for, as the cyanosis and the œdema increase, the greater is the resulting bulk of the tumour, and so it progresses until, in the absence of relief, the child is choked or succumbs from cardiac exhaustion.

TREATMENT The problem of treatment is an exceedingly difficult one. Any attempt at radical treatment in the shape of removal of the tumour is of course impossible, and even measures of relief are difficult and often unavailing. Dyspnoea may be temporarily improved by performing a tracheotomy and introducing a catheter to such a depth that the site of obstruction at the upper aperture of the thorax is passed.

On two occasions we have attempted a more direct relief of pressure by dividing the sternum about the level of the third costal cartilage, by severing the costal cartilago on each side above that level, and by freeing the clavicles from their attachments to the sternum. The bony plate which overlies the tumour is thereby allowed to project forwards and an additional amount of space is thus provided. A more ideal method would be to remove the isolated block of bone and subsequently to submit the tumour, now directly exposed, to X ray treatment. Even though the eventual outlook is obviously hopeless, the suffering of the child is so distressing that the surgeon feels he must make some effort to relieve the symptoms.

(e) **Status Thymo-lymphaticus** There are three separate conditions which are often included under this heading, and in the literature a good deal of confusion has arisen. A simple hyperplasia of the thymus may exist without any associated changes in the general lymphatic system (*the status thymicus*), the lymphatic system may be enlarged without concomitant change in the thymus (*the status lymphaticus of Patau*), or the thymic hyperplasia may be combined with a hyperplasia of the entire lymphatic system (*the status thymo-lymphaticus*).

From the surgical standpoint importance attaches to those conditions which are associated with thymic enlargement, whether it be the simple status thymus or the status thymo lymphaticus, because it is in these conditions that pressure symptoms occur, and that the tragedy of sudden death is so common.

THE CLINICAL FEATURES Children who suffer from thymic enlargement may or may not show evidence of it in their general appearance: those who demonstrate distinctive general features are subjects of the status thymo lymphaticus. They are pale, well nourished children, somewhat above the average height, the skin is thick and pasty looking, the hair deficient, the nervous system is impaired, and they are slow and deliberate in their movements. For some reason the cardiac function is easily impaired.

The history is distinctive in all examples of thymic enlargement,

whether simple or complicated by lymphaticus. During the first two years of life a record is obtained of attacks of dyspnœa, which may have been so severe that death has almost occurred, or so slight that they were but passing manifestations. They are most common during sleep, and especially if the head is placed in an extended position, or they may occur during fits of crying or coughing. These attacks are due to pressure exerted by the thymus upon the soft compressible windpipe of the young child. It is probable that the gland rises or is pulled as a wedge into the upper aperture of the thorax, and, as the outlet in the child measures only two to three cms. in width, and as it is completely unyielding in front, the pressure of the impacted thymus is exerted upon the trachea with resulting dyspnœa symptoms.

The enlarged thymus has another effect which produces symptoms—it exerts an irritating influence upon the inferior laryngeal nerves; the effect of this is to induce a stimulation of the constrictive impulses so that spasmodic closure of the glottis results: the dilator impulses of the nerves are apparently less responsive, and their function is therefore not affected.

Every now and then the clinical history is closed by the tragedy of sudden death. This may happen during sleep or the induction of anæsthesia, or as the result of some unusual stimulus or exertion. Much time and research have been expended in investigating the cause of death in such circumstances. In some instances, tracheal obstruction may be responsible, but there are many cases in which it is apparent that such a direct mechanical influence is absent. It has been suggested that pressure of the gland on the base of the heart, causing an irritation of the cardiac ganglia, may be the cause. Wiesel has advanced the interesting hypothesis that the thymus hyperplasia is associated with a depression of the sympathetic nervous system from diminished adrenalin secretion, and that an uncontrolled vagus impulse is permitted which causes cardiac arrest. McNeil believes that thymus death is due to anaphylactic phenomena occurring in exaggerated form. We have no definite proof of any of these various views, and in many cases the real cause of death remains undecided.

From the practical surgical point of view the importance centres round two points:—

- (1) That thymus enlargement is responsible for recurrent attacks of dyspnœa; and
- (2) That in those who suffer in this way death may occur in the most sudden and unlooked-for manner.

EXAMINATION. In the presence of a history such as we have attempted to outline, attention is directed to the possibility of a thymic enlargement, and it should be possible to demonstrate its presence. Apart from the general appearance, if the condition is one of status thymo-lymphaticus, there are several local signs. Percussion in the upper midline of the chest reveals a dull area, which corresponds

to the position of the thymus, and auscultation shows that over this area there is heard prolonged expiration with tubular breathing. If the finger is placed in the supra sternal notch a thymic impulse may be appreciated when the child cries, coughs, or even swallows. It is, however, by X ray examination that the most reliable clinical evidence is obtained, because the enlarged thymus is apparent as a shadow in the upper and middle reaches of the thorax.

DIAGNOSIS It is important to exclude other possible causes of dyspnoea apart from thymic enlargement. Congenital laryngeal stridor is a pure inspiratory phenomenon, and is associated with a congenital malformation of the upper aperture of the larynx (laryngismus stridulus). Adenoids, pre vertebral abscess, and pressure from enlarged tracheo bronchial glands also require to be excluded, but the clinical history and a careful routine examination will prevent confusion.

TREATMENT The problem of treatment is a difficult one, because the only really effective treatment is removal of a portion of the thymus gland, and this being an unusual operation, it does not commend itself to the average individual, whether parent or doctor. There are, however, certain lines along which treatment, both precautionary and active, may run.

If the practitioner judges from the evidence available that a child is suffering from a hyperplasia of the thymus, it is his duty to warn those intimately connected with the patient of the risk which it runs. For the first five or six years of life, the child should be carefully guarded from harmful or even unusual stimuli of any kind, in sleep it should be provided with a high pillow, and general anaesthesia is to be avoided unless its use is imperative. The child's baths should be warm, as sudden immersion in cold water is peculiarly dangerous. Apart from these precautionary measures, there is comparatively little of a non-surgical character which can be done, though extract of thymus has been employed, and the use of adrenalin has been recommended (Wiesel). It has been suggested that exposure of the upper part of the chest to X ray would be beneficial, because it reduces the size of the gland, but the dangers associated with prolonged X ray exposure in children have hitherto limited this method of treatment.

Surgical Treatment Partial removal of the thymus is neither a difficult nor a dangerous operation, and as it is the only efficient method of treating thymus hyperplasia, it will probably be more widely adopted as its satisfactory results become appreciated. The operation should be performed deliberately before symptoms become urgent, for, if performed as an emergency measure when the child is already *in extremis*, the results are naturally disappointing. It should not be carried out if tracheotomy has previously been necessary, because an infective mediastinitis is likely to follow.

The operation is simple and rapid. A transverse supra sternal incision is made, the edges retracted, and the superficial cervical

fascia divided medially and vertically; the raphe between the pre-thyroid muscles is opened, and the muscles are retracted laterally. A rounded swelling is now seen bulging upwards with each expiration and disappearing again with each inspiration—this is the thymus gland. Its capsule is grasped in curved forceps, and the gland is gently pulled upwards, after which the removal of the necessary portion is carried out by either the extra-capsular or the intra-capsular method; the former is preferable, but its use is contra-indicated if adhesions exist. By the *extra-capsular method*, the gland is gently separated until sufficient is isolated, hæmorrhage being arrested by clamping every portion of loose connective tissue in contact with the thymus. By the *intra-capsular method*, the capsule is incised between two forceps, and enucleation is performed with a dissector. When sufficient gland has been separated by either method, the pedicle is carefully ligatured, and the free portion removed. The operation is completed by closure of the muscle layer and suturing of the skin. Drainage should be established for twenty-four hours.

fascia divided medially and vertically; the raphe between the pre-thyroid muscles is opened, and the muscles are retracted laterally. A rounded swelling is now seen bulging upwards with each expiration and disappearing again with each inspiration—this is the thymus gland. Its capsule is grasped in curved forceps, and the gland is gently pulled upwards, after which the removal of the necessary portion is carried out by either the extra-capsular or the intra-capsular method; the former is preferable, but its use is contra-indicated if adhesions exist. By the *extra-capsular method*, the gland is gently separated until sufficient is isolated, hæmorrhage being arrested by clamping every portion of loose connective tissue in contact with the thymus. By the *intra-capsular method*, the capsule is incised between two forceps, and enucleation is performed with a dissector. When sufficient gland has been separated by either method, the pedicle is carefully ligatured, and the free portion removed. The operation is completed by closure of the muscle layer and suturing of the skin. Drainage should be established for twenty-four hours.

Congenital Anomalies of the Ribs Various configuration errors of the ribs arise in association with congenital scoliosis. Individual ribs may be absent, two or more may be fused, or bridges of bone may bind several of the ribs together. Greig has described the formation of the ribs in the neighbourhood of the shoulder-blade in cases of congenital elevation of the scapula. Except in relation to their association with congenital scoliosis, the errors are of no practical importance.

Supernumerary Cervical Ribs Supernumerary cervical ribs are estimated to exist in 1 to 2 per cent. of children, but in only a very small percentage do symptoms arise during childhood. The abnormality is insufficiently developed at this early age, though the possibility of its occurrence has to be kept in mind as explanatory of pain referred to the distribution of the first dorsal root, or of



FIG. 364.—Cervical Rib of the right Side (After Schult e)

muscular wasting or paralysis affecting the small muscles of the hand and particularly the opponens pollicis and the abductor pollicis.

TREATMENT Most cases respond to conservative treatment, though the improvement may be temporary. We have not had an opportunity of tracing cases into adult life, but they certainly improve rapidly at an early age by such simple means as—

- 1 Raising the shoulder girdle upwards and backwards by means of a sling
- 2 Exercise development of the trapezius and the levator scapulae muscles, so that the strain on the plexus root is removed

If these measures fail, an operation for removal of the rib may have to be carried out.

ACQUIRED DEFORMITIES OF THE CHEST

Rickets is the disease which is responsible for most of the acquired deformities of the chest wall. A degree of respiratory obstruction is often superadded, so that the influence of various respiratory muscles,



FIG. 362.—Mammary Abscess in Child 6 weeks old.

costal cartilages are deficient, the middle line being occupied by a fibrous membrane and the integument. A proportion of the children show congenital heart lesions.



FIG. 363.—Hamangioma of the Chest Wall.

No surgical treatment has been reported in connection with these cases, but, if the deficiency gives rise to alarm, it should be possible to carry out some type of bone-grafting procedure.

Ectopia cordis, an error incompatible with life, is associated with complete absence of the sternum.

Cleft Sternum. The sternum is developed in two lateral halves, and failure of the two parts to unite results in the appearance of a cleft sternum. The error is somewhat serious, because it is associated with underlying visceral displacement.

The condition of *sternal foramen* is a slight form of the same error. A round orifice, large enough to admit the tip of the little finger, exists in the mid-line near the attachment of the ensiform appendix.

Congenital Anomalies of the Ribs Various configuration errors of the ribs arise in association with congenital scoliosis. Individual ribs may be absent, two or more may be fused, or bridges of bone may bind several of the ribs together. Greig has described the formation of the ribs in the neighbourhood of the shoulder-blade in cases of congenital elevation of the scapula. Except in relation to their association with congenital scoliosis, the errors are of no practical importance.

Supernumerary Cervical Ribs Supernumerary cervical ribs are estimated to exist in 1 to 2 per cent of children, but in only a very small percentage do symptoms arise during childhood. The abnormality is insufficiently developed at this early age, though the possibility of its occurrence has to be kept in mind as explanatory of pain referred to the distribution of the first dorsal root, or of



FIG 364—Cervical Rib of the right Side (After Schultze)

muscular wasting or paralysis affecting the small muscles of the hand and particularly the opponens pollicis and the abductor pollicis.

TREATMENT Most cases respond to conservative treatment, though the improvement may be temporary. We have not had an opportunity of tracing cases into adult life, but they certainly improve rapidly at an early age by such simple means as—

- 1 Raising the shoulder girdle upwards and backwards by means of a sling
- 2 Exercise development of the trapezius and the levator scapulae muscles, so that the strain on the plexus root is removed

If these measures fail, an operation for removal of the rib may have to be carried out.

ACQUIRED DEFORMITIES OF THE CHEST

Rickets is the disease which is responsible for most of the acquired deformities of the chest wall. A degree of respiratory obstruction is often superadded, so that the influence of various respiratory muscles,

together with atmospheric pressure, is exerted upon the imperfect osseous framework.

Rachitic Deformities. As the result of rickets, the thorax is compressed laterally, particularly in the mid-region, the back is flattened, and the sternum becomes unduly prominent. The resulting section outline is that the antero-posterior diameter of the chest is increased at the expense of the lateral. The rachitic rosary is usually noticeable, and a Harrison's sulcus is evident below the nipples.

Pigeon Breast (Pectus Carinatum). This deformity is comparatively



FIG. 365.—Cervical Rib (left) (Boy aged 15 years).
A characteristic group of symptoms and signs appeared in this case.

common in children. It is characterized by an increase in the antero-posterior diameter of the chest with a diminution of the lateral, so that the sternum with the costal cartilage is carried forwards. The deformity occurs in association with rickets particularly when respiratory obstruction from enlarged tonsils and adenoids co-exists. A type of pigeon-breast arises in connection with the kyphosis of tuberculosis of the upper dorsal spine, and a lateral type of the deformity is produced when a scoliosis accompanies the chest error.

Funnel Chest (Pectus excavatum). The term is applied to a deformity in which the sternum is depressed below its normal level, the costal cartilages being indrawn in company with the sternum. It is obvious

that the lateral diameter of the thorax is increased while the antero-posterior is diminished. The cause of the deformity has not been satisfactorily explained, congenital influences may be at fault, and respiratory obstruction is a possible factor.

Flat Chest This deformity of the chest is met with in association with round shoulders, the error is discussed in connection with disease of the spine.

TREATMENT All of the above-mentioned deformities respond well to treatment by various corrective exercises. No operative treatment is of any value.

Changes in the Chest Wall associated with Scurvy In severe cases of scurvy a series of fractures may occur at the atrophied anterior ends of the ribs. In this event the sternum and costal cartilage are displaced backwards, while a number of prominences along the



FIG. 366.—*Tumour of the Lung*

The shaded areas represent the outline of a tumour of the left lung in a child 10 years old. The tumour proved to be a myxoma.

line of the costo chondral junction give an impression similar to that produced by a rachitic rosary.

In association with the same disease, tender swellings may appear along the line of the ribs—they are the result of sub periosteal hæmorrhages.

Fractures of the Ribs Fracture of the ribs is uncommon in children except in association with rickets and osteogenesis imperfecta. The injuries are multiple, occurring close to the angles of the ribs, and in all probability they result from lateral compression of the chest by the hands while the child is being lifted.

EMPHYEMA

The occurrence of emphyema in childhood is by no means infrequent, but it is less serious than the same disease in adults, and responds more readily to treatment.

DEFINITION AND ORIGIN

The term empyema is intended to imply the accumulation of purulent fluid between the visceral and parietal pleuræ or between the reduplication of the visceral layers (an interlobar empyema). According to the extent and distribution of the effusion, the empyema is said to be *encysted* or *diffuse*.

It is convenient to recognize varieties of the disease according to the route by which the infection has gained entrance, and on this basis the possibilities are as follows:—

(1) The disease may be a direct infection from a lesion of the underlying lung, as in pneumonia; this is the common method of infection in childhood.

(2) The infection may be borne by the posterior abdominal lymphatics from a focus of abdominal disease. This happens when the disease is secondary to appendicitis, peritonitis, and sub-phrenic abscess.

(3) The empyema may be a blood-borne infection, and therefore a complication of scarlet fever, measles, and septicæmia. In this connection it is difficult to exclude the possibility of a pre-existing underlying pulmonary lesion, but there is evidence that an independent blood-borne infection may occur.

(4) The infection may be secondary to disease of the chest wall, as, for example, osteomyelitis of the ribs or spine.

PATHOLOGY

In its early stages, the pathology is that of the infection of a serous membrane. Congestion of the visceral layer is followed by the deposit of lymph on the surface of the membrane, and by the accumulation of fluid in the pleural space. As the effusion of fluid becomes purulent, additional amounts of fibrinous lymph are deposited upon the pleural surface, and as the result of the friction caused by the respiratory movements, the deposit becomes collected into masses of plastic material which remain attached to the pleural surface or lie loose in the fluid.

If the inflammatory products are left indefinitely in contact with the serous surface, they become organized so that the visceral pleura especially is covered with a layer of vascular granulation tissue. Fibrosis of this tissue follows, and the lung becomes virtually encased in a covering of dense unyielding tissue. In a long-standing case, the fibrous change of the surface extends into the interior so that the complete lung on the affected side becomes fibrotic and contracted.

A study of the pathology teaches one lesson in particular—that if the functional value of the lung is to be retained, the septic process must be relieved at as early a stage as possible.

If the case remains untreated or unrecognized, the pus finds an outlet along certain recognized tracts; it may perforate the chest wall,

usually at the point of superficial exit of one of the intercostal nerves, or it may make its way into the air passages or into the œsophagus

BACTERIOLOGY

In a recent investigation of the bacteriology, as illustrated by seventy cases, the pneumococcus was found to be present in fifty three, while in seventeen the streptococcus was the infecting organism. The occurrence of other organisms is rare—infections which originate in the chest wall sometimes demonstrate a staphylococcus, while an empyema which is secondary to abdominal disease may show the bacillus coli communis, in certain instances, anaerobic organisms are found, but their entrance is usually a secondary feature

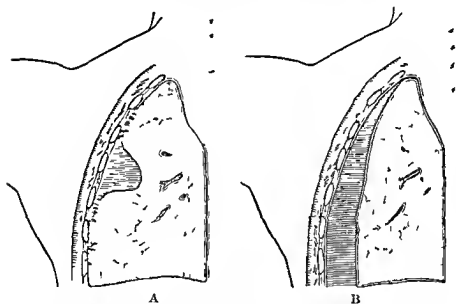


FIG 367—Diagrammatic representation of (a) Locysted Empyema, (b) Diffuse Empyema

FEATURES RELATED TO THE BACTERIOLOGY

Prognosis The infecting organism is intimately related to the prognosis, in the analysis alluded to above, it was found that in fifty three pneumococcal cases the mortality average was 6 per cent, while in seventeen streptococcal cases it was 24 per cent—a striking dissimilarity, for which the type of organism is directly responsible

In the pneumococcal group it is important that we should have further information regarding the relative mortality of the different types of pneumococcus. The knowledge which we have, indicates that the outlook is most favourable in type 1, partly perhaps because this organism is peculiarly responsive to serum treatment

Pathology The type of infecting organism is generally associated with a distinctive pathology. The fact has become well recognized

that where a streptococcal infection exists the pleural effusion is widespread and adhesions are few, while in a pneumococcal case the empyema is likely to be limited by dense and extensive adhesions. The consideration has important bearings upon subsequent treatment.

Incidence Factors. The general incidence of the disease is a matter of interest. In relation to the general occurrence of surgical disease the development of empyema is comparatively rare; on an average 1,000 cases pass through the surgical wards of the Children's Hospital each year, and of these the examples of empyema average 15 to 20 cases. But there is another aspect of the incidence which is of greater clinical interest. The vast majority of examples of empyema are secondary to infection of the underlying lung, and we have thought it of interest to attempt to answer the question—what types of acute lung infections are most liable to develop empyema? It is but fair to say that our figures have been chiefly derived from hospital classes.

Dividing the common acute lung infections of the child into three groups—acute lobar pneumonia, acute broncho-pneumonia, and the acute pneumonia of influenza—we find the following incidence, and we think the figures are of interest:—

TABLE I

Following lobar pneumonia	15 cases	..	21 per cent.
„ broncho-pneumonia	38 „	..	54 „
„ influenzal pneumonia	17 „	..	24 „
<hr/>			
Total cases of empyema	70 „		

It would seem that the broncho-pneumonic infections are those most liable to be followed by empyema. The figures must be taken tentatively, because the incidence is necessarily affected by questions of age and the general health of the child, yet the divergence of the different groups of figures is distinct and striking, and the percentages run parallel with those published by Mounetier. It is interesting to speculate on the influences which affect the incidence of empyema in relation to the original disease. It may be that the broncho-pneumonic lesion affects the more debilitated type of child, and that the empyema is but an indication of a general want of vitality, but an explanation has been offered which is based on the peculiarity of pathology of each variety. It is said that in a lobar pneumonia the massive congestion and consolidation limit and confine the infection, while in the more diffuse broncho-pneumonic variety the barriers are less complete, and there is greater opportunity for infection to extend to the surface and especially to the fringes of the lung around the fissures, where an empyema usually begins. Our interest in this question has been considerable, because we realize that this is not the usual conception, it being generally stated that the lobar type of pneumonia is commonly responsible for the later development of empyema.

CLINICAL HISTORY

The disease may appear at any age, even in the first week of life. It is most common in the ill developed and underfed type of child, and the city dweller is affected in greater proportion than the country child.

SYMPTOMS

Whatever may have been the introductory features of the case, the actual onset of the empyema is evidenced by pyrexia, malaise, loss of weight, and the appearance of general illness, profuse night sweats may occur. If the child is old enough he may complain of pain over the affected side of the chest, a cough is usually present.

PHYSICAL SIGNS

The characteristic signs of an empyema are an area of dullness with diminished breath sounds, and defective vocal resonance, and a diminished movement of the chest wall on the affected side. If the amount of fluid is large, bulging of the chest wall may be apparent, in chronic cases the affected side may be shrunk owing to pulmonary collapse. In most cases the heart is displaced in acute cases with much fluid towards the healthy side, in chronic cases with pulmonary collapse towards the affected side. Every case should be submitted to X ray examination, for the collection may be apparent as a shadow. The examination will conclude with an exploratory puncture of the chest, by this means the locality of the fluid is exactly defined, certainty of diagnosis is ensured, and (what is especially important from the point of view of treatment) evidence is obtained of the nature of the infecting organism. As the pus is frequently thick, a hollow needle of large bore should be used, and the specimen obtained should be at once examined bacteriologically.

DIAGNOSIS

The recognition of an ordinary empyema is usually easy—the common association with pneumonia, the demonstration of local dullness, the appearance of a shadow on X ray examination constitute a group of clinical features which at once suggest an empyema. The diagnosis should not be finally made until an exploratory puncture of the suspected area has revealed the presence of pus.

Real difficulties arise in the recognition of the *interlobar* variety, where the pus accumulates between the lobes of the lung. A surface layer of healthy lung tissue may overlie such a collection, and it is easy to imagine how the signs of the underlying empyema may be hidden, it is in this class of case that X ray examination is especially valuable.

The conditions which simulate empyema are a lobar pneumonia, a pleurisy with effusion, bronchiectasis, and tumour of the lung.

X-ray examination and exploratory puncture are the means by which a differential diagnosis is made.

PROGNOSIS

In the ordinary course of events the prognosis is serious but not grave. Certain considerations affect the gravity of the individual case, these being, age, the responsible organism, the preceding disease, and the situation of the collection.

Age. Infants are intolerant of any septic condition, and therefore the mortality of empyema is highest in the first two years of life.

The Organism responsible. Pneumococcal infections present a favourable prognosis; the mortality is considerable in streptococcal infections, particularly in the case of the streptococcus hæmolyticus. Staphylococcal infections are generally unfavourable, and at the best a complete recovery is long delayed. An empyema which is associated with an anærobic infection, though severe at the time, often responds readily to operation.

The preceding Disease. If the preceding disease is a local pulmonary infection such as a pneumonia, the outlook is good; on the other hand, the empyema which succeeds a general infection such as scarlet fever is serious. In the case of empyema which is secondary to an abdominal infection the prognosis is unfavourable.

The Situation of the Collection. Apical and anterior collections are more serious than the basal and posterior varieties.

TREATMENT

If the surgical treatment of empyema is to be successful, it is essential that individual consideration be given to each case. In fact, the details of operative treatment must not be finally decided upon until certain data are available. The surgeon who says, 'Here is an empyema; all that is required is to open the pleura and permit the escape of the pus' is courting disaster in a considerable proportion of cases, because different conditions call for different modes of treatment. The points upon which knowledge is required before the line of treatment can be chosen are three in number:—

- (1) What is the general condition of the child?
- (2) What is the type of infecting organism?
- (3) Are adhesions present to any extent between visceral and parietal pleuræ?

The importance of the first question is obvious: it is a query which is very properly raised before surgical interference of any gravity is undertaken, and the answer to it is supplied by the results of the routine examination of the child. The answer will necessarily modify our choice of treatment, because a precarious general condition may preclude anything but the simplest and briefest of relief measures, and these possibly only temporary in their character.

The answer to the second question—that of the infecting organism—has already been alluded to, and its importance has been emphasized. Because of the important information which the answer provides, no operative interference should be carried out until the result of the bacteriological examination is available. The pus which is obtained from the diagnostic puncture of the chest is the source from which the information is obtained.

There are two ways in which direct information may be obtained upon the third point—by X ray examination, and by investigation of the intra pleural pressure. The X ray investigation is uncertain in its results, it may show evidence which makes the answer clear, and by the method of lateral projection, and with the aid of the Potter-Buckley diaphragm, the value of its evidence has been vastly increased, but a certain proportion of cases inevitably remain in which the X ray evidence as to the existence or absence of adhesions is imperfect, and it is in these that *the estimation of the pleural tension* may give valuable information.

The Estimation of Intra-pleural Tension A hollow aspirating needle of large bore (15 gauge) is inserted into the effusion within the pleural cavity, and connected by a length of thick rubber tubing to a water manometer. The pressure which is recorded is naturally of a positive character, and it varies within wide limits according to the amount of fluid which the chest contains. On an average it registers about 10 cms of water. The information which is so valuable, however, is in regard to the oscillation of the fluid, for the pressure curves tell whether adhesions do or do not exist. In the absence of adhesions the play of the respiratory oscillation is a wide one, varying from a negative 5 to a positive 10. When adhesions are present so that the visceral and parietal surfaces are maintained in contact over a wide area, the pressure rhythm is different, remaining at a constant pressure with comparatively little variation. The charts shown on page 682 illustrate the distinctive readings obtained from different types of cases.

The physical explanation of the phenomenon is as follows. Normal intra-pleural pressure is dependent on the elastic recoil of the lungs. In the infant the intra pleural tension is practically zero, as the lungs completely fill the thorax. With increasing age the thorax seems to grow away from the lungs, and a negative intra pleural tension is created. By expansion of the chest and descent of the diaphragm during inspiration the lungs are stretched, their power of elastic recoil is increased, and the negative intra pleural tension is correspondingly raised, so that in the healthy child of five years the intra pleural tension varies from -5 mm of mercury with inspiration to -2 mm with expiration. When fluid accumulates within the pleural cavity, the relationship is altered, so that a positive pressure is recorded during expiration, while it falls to a negative level during inspiration. If adhesions do not exist, the

rhythmic rise and fall is maintained, but the levels are exaggerated ; if, however, the lung is bound down to the chest wall, its natural elastic recoil is interfered with, and the oscillation of the tension is thereby diminished. The investigation of the intra-pleural tension is a method which promises to afford us reliable information upon the all-important question of the presence or absence of intra-pleural adhesions.

The practical result of these investigations is the possibility of dividing cases of empyema into two groups—*Group A*, in which the

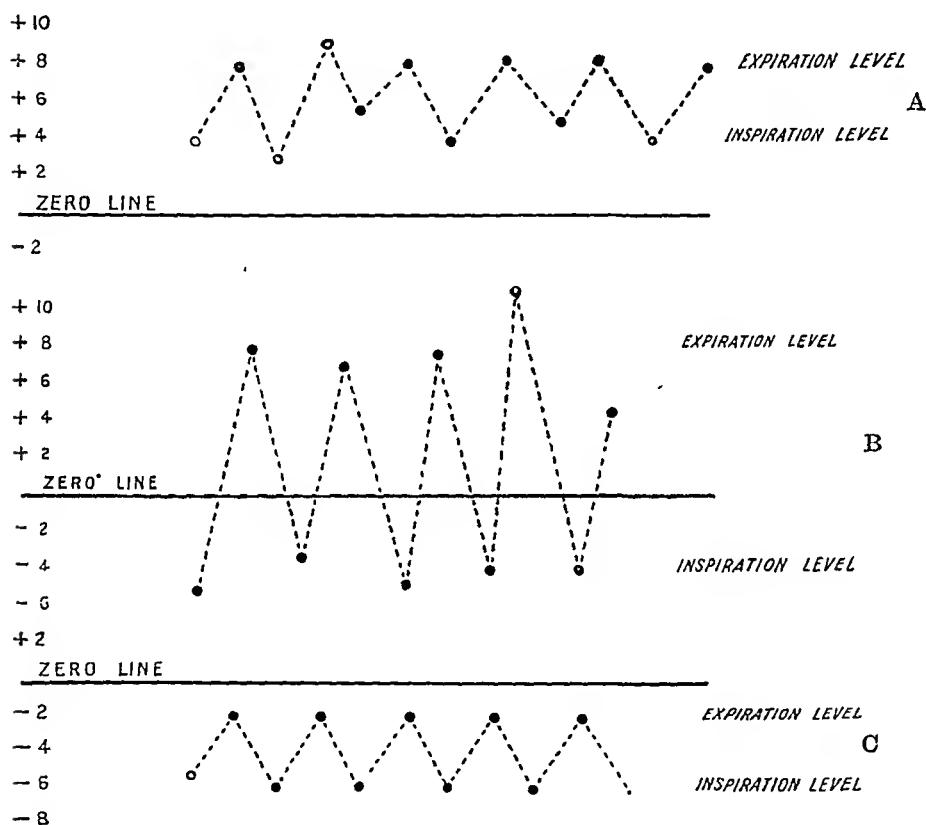


FIG. 368 (A, B and C).—Records of Intra-pleural Pressure Readings.

A. Reading in case of Encysted Empyema. B. Reading in case of diffuse Empyema.

C Normal reading.

effusion is localized by surrounding adhesions, the pneumococcus being the organism usually present, and *Group B*, in which the effusion is widely distributed owing to the comparative absence of adhesions, the streptococcus being the common infecting organism. We believe that these two groups of cases must be treated in different ways.

The Procedure in Group A (the Adhesive Group)

In this event the ideals for which we strive may be summarized as follows : To open freely into the abscess cavity either by resection of a rib or through an intercostal thoracotomy ; to evacuate the pus,

and any masses of fibrin which are adherent to the pleura or are lying free within the exudate, to establish a *closed* drainage from the most dependent part of the cavity, and to close completely the original wound after disinfecting the edges. We assume that the most perfect result which can be attained after the operation for empyema is one in which the wound closes in a reasonable period of time (twenty one days), and in which no potential intra pleural cavity remains, because the lung has expanded so as to come into contact with the chest wall throughout its extent. We believe that by the method which we have outlined the desired result is most efficiently secured.

The practical Details of Treatment The operation is performed under gas and oxygen anæsthesia, local anæsthesia has certain advantages over any general anæsthetic, but its use in children in this connection is surrounded by many difficulties. The incision is made over a point which corresponds to the *centre* of the cavity. The incision may be made over the rib or over the centre of the related intercostal space, a portion of rib may be excised, or the intercostal route may be followed. Our practice has been to employ the muscular intercostal route, in the pliable thorax of the child it gives sufficient access, and it avoids the risk of infection of the cut surface of the ribs, a complication which is sometimes responsible for the persistence of infection. In the adult, where intercostal access is more difficult, rib resection is advisable. Whichever route is followed, the

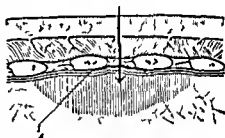


FIG. 369.—Method of Opening into the Empyema Cavity

The parietal pleura is separated from the chest wall for a radius of several centimetres before the membrane is opened (A Line of Separation)

dissection is deepened until the surface of the parietal pleura is exposed. There then follows a step in the operation to which considerable importance must be attached. The parietal pleura is separated from the chest wall for an area of about $1\frac{1}{2}$ inches around the incision, the pleura, in fact, is mobilized from the deep surface of the chest wall. This detail prevents retraction of the pleura and permits of later closure, a point which is essential to the ultimate success of the case. We sometimes anchor the separated pleura by two laterally placed sutures.

The pleura is now incised in the long axis of the wound, the pus is evacuated, and the interior of the cavity is gently swabbed with pledgets of gauze upon long handled forceps so as to remove the masses of infected fibrinous clots which are lying loose in the cavity or are adherent to the surface of the underlying lung. Removal of this infected debris is essential, because retention of it within the cavity may mean the persistence of infection until resolution takes place, as many of the masses are too large to be extruded through the drainage tube. The cleansing process must be carried out with gentleness

and care, because it is important to conserve the adhesions which exist. When the operator is satisfied that the cavity has been sufficiently cleared, a closed drain is inserted through an independent opening

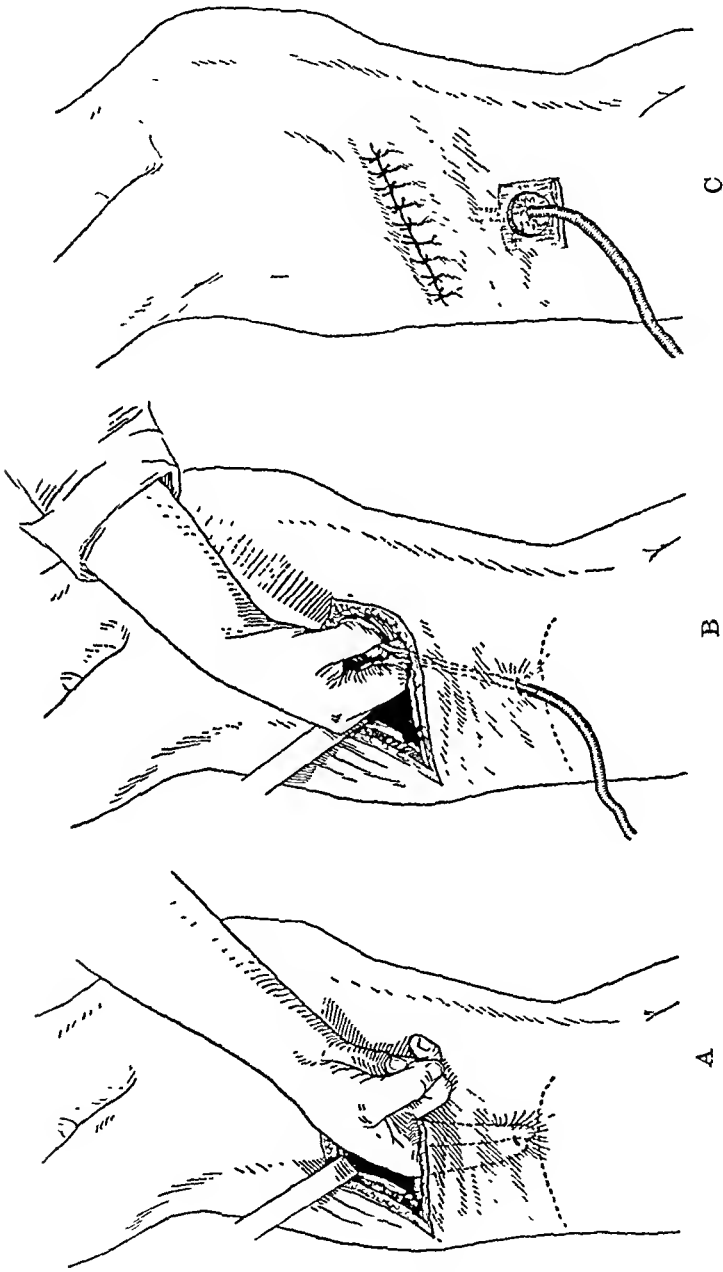


FIG. 370 (A, B and C).—Empyema. Diagrammatic representation of the steps in the introduction of the Drainage Tubes. (By permission of *Edinburgh Medical Journal*.) This method was first described by Dr. O C Pickhardt of New York (*Archives of Surgery*, Vol. 8, pp 293-302), of whose work the author desires to make acknowledgment.

placed at the lowest level of the cavity. One finger is passed through the original wound, and a stab puncture wound is made through an intercostal space at the proper level, or a long-handled bent forceps is used in a similar way. Through this new wound a large-sized rubber

drainage tube is guided, so that it lies just within the interior of the abscess cavity, the skin edges are sutured tightly around it, but no sutures are placed through the drain, the outer portion of the tube may be threaded through a flat piece of cork, or a special flanged tube may be used. The tube is clamped until the further stages of the operation are completed. The original wound is now carefully closed. Accurate approximation of the pleural edges is essential, otherwise infection will make its way to the surface, the wound will break down, and the entrance of air will result in the development of a pneumothorax. As it is unlikely that independent sutures will hold in the friable pleura, the stitches are inserted so as to pick up the intercostal fascia and even to include the rib above—this point is made clear on reference to the diagram. The edges of the wound are treated with B I P P, and a small strip of rubber is inserted as a superficial drain for forty-eight hours.

The after treatment is simple. The single drainage tube is conducted so that its free end lies beneath a vessel containing a weak antiseptic, the child is nursed in a sitting up position. The upper and larger wound usually heals by first intention, and the drainage tube is kept in place for fourteen to twenty-one days.

In our experience the results of this method have been eminently satisfactory. The temperature falls, the pneumothorax which the thoracotomy produced disappears as the lung expands. As the child coughs or cries, bubbles of air escape from the tube, and the fluid trap prevents the re-entrance of air. After a time, which varies from twenty to twenty-eight days, the pneumothorax has disappeared, and the lung has expanded so as to fill the cavity of the chest.

The attractions of the method are that it permits full exposure of the cavity, thorough cleansing of the interior, free dependent drainage, gradual disappearance of the pneumothorax, all of these advantages being secured without incurring risk of the entrance of air into the chest. The method in fact permits and actually encourages that early expansion of the lung without which a satisfactory result cannot occur.

The Procedure in Group B (the Non-adhesive Group)

One distinctive point in pathology—the absence of adhesions between visceral and parietal pleura—controls the treatment in this class of case. To open the chest primarily with a free incision is to court disaster, because the absence of adhesions permits of such an extensive collapse of the lung that an early fatal result is likely to ensue.

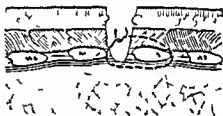


FIG. 371.—Method of Closure of the Chest Wound

The deep catgut suture includes an adjacent rib

We therefore persevere with aspiration for four or five days ; the effusion is probably thin, and the bulk of it can be got rid of by aspiration. By the fourth or fifth day adhesions have developed to such an extent that the chest may be opened with a considerable margin of safety, and thereafter the procedure is very similar to that described above, except that the separation of fibrinous masses must be carried out as carefully as possible in order to prevent the breaking down of the recently formed adhesions. The after-treatment is similar to that described in Group A.

Other Methods of Treatment. In our search for a satisfactory



FIG. 372.—The Treatment of Empyema by the Closed Method.

The tube, which leaves the chest by a stab wound below the original incision, passes underneath antiseptic fluid in the attached bottle. (From *Edinburgh Medical Journal*.)

method of dealing with empyema in children we have given a trial to most, if not all, of the other recognized procedures, and it has been our experience that the various methods possess serious disadvantages. *Simple thoracotomy with open drainage*, whether intercostal in position or by resection of a rib, is associated with many strong objections. The pneumothorax which is established remains for a long time, mixed infection is inevitably introduced, a sinus may persist for months or years, and the chances are that the lung is bound down by a thickened pleura under which it never fully expands. *The method of primary closure without drainage* has been disappointing. It has not fulfilled the expectations which at one time it appeared to

hold out. Occasionally it gives a brilliant result, but its failures more than counterbalance its successes. The objections to it are that it is associated with a considerable immediate mortality, that a certain proportion of the wounds break down, a sinus developing which results in the production of the pneumothorax one is so anxious to avoid, in a few cases the closure of the wound is followed by the exaggeration of sepsis within the chest, so that secondary drainage is called for. The *trochar and cannula method*, by which a large sized cannula is inserted between the ribs and a self retaining Pezzar's catheter is threaded into position through the cannula, has been introduced in an attempt to combine the advantages of the open and closed methods, but it has not proved a success, because the drainage which is established is insufficient. It is, moreover, associated with a practice of doubtful value—that of syringing the cavity at intervals each day with a solution of hypochlorous acid in order to dissolve the fibrinous and purulent debris. Some degree of pneumothorax is inevitable if this method is practised. *Simple aspiration frequently repeated* is favoured by many physicians. In mild infections treated at an early stage in their progress before fibrinous masses have formed the method is often successful. It will, however, almost necessarily fail if any infected fibrinous material exists in the cavity.

In French and American literature much has been written regarding the value of *irrigation of the infected serous cavity* with solutions of the aniline dyes. Gentian violet (1 in 2,500) has proved the most efficacious. The pus is evacuated as completely as possible, 30 to 50 c c of the dye are then injected along the needle into the cavity, after forty eight hours the procedure is repeated.

Serum Treatment. Severe cases which show signs of general infection should be given the benefit of serum treatment. In pneumococcal infections typing of the organism is an essential preliminary, and in type 1 cases, serum treatment has given excellent results. In streptococcal cases and in pneumococcal cases where special serum is not available normal horse serum may be tried.

After-treatment of Empyema Cases

The ideally successful case is one in which the lung expands so as to fill the thoracic space, while the septic process of the pleural surface subsides and discharge ceases. Care in the details of after treatment is an important link in the attainment of this success.

The child is nursed in a sitting up position. Morphine should not be used unless the pain is severe, because it is desirable that the affected lung should function as fully as possible, if the child cries the effect on the lung is to some extent beneficial.

The dressings are secured with a binder. Circular bandages should not be used, as their removal necessitates a good deal of disturbance, and it is difficult sometimes to avoid a degree of harmful circular compression. A recent modification of the dressing arrangements is the

use of a costal shield, which, moulded of reinforced poro-plaster or of plaster of Paris, and taking its fixed points from the crest of the ilium and from around the shoulder, is applied to half of the chest on the healthy side, being so adjusted that it admits of full expansion of the lung. When the shield is in place a circular bandage or a binder can be applied so firmly that while it compresses the chest on the affected side and so perhaps helps to obliterate the cavity of the empyema, no pressure is felt by the healthy side, because it is protected by the shield. The method is of value in cases in which it is desirable to obliterate a cavity by inducing collapse of the chest wall.

Advantage should be taken of position in encouraging emptying of the empyema cavity, and therefore from time to time the child lies on the affected side. Breathing exercises and the use of any mechanical appliance which will aid the expansion of the lung are to be recommended. In the case of young children it is difficult or even impossible to induce them to follow any regular system, but they may be given balloons to blow up, or the small-sized James's bottles may be filled with a brightly coloured water, and they amuse themselves by attempting to blow the fluid from one bottle into another.

Persistence of Discharge. Disappointment arises in a certain proportion of cases because the empyema sinus does not close within a reasonable time. One asks oneself why this should occur. There are three possible explanations:—

- (1) Septic material may be retained within the cavity, in which case it is usually in the form of septic masses of fibrin.
- (2) There may be a fixed cavity which cannot be obliterated because the lung will not expand or the chest wall will not collapse.
- (3) There may be the error known as a 'wheel rib'—formation of bone occurs on the ribs adjacent to the point of drainage, and as a result a complete ring of bone develops, which prevents closure of the sinus. This complication is most commonly met with when rib resection has been carried out, and long-standing tubular drainage has been used.

In view of these possible explanations, each case of persistent discharge should be carefully reviewed. The chest wall is X-rayed, and the possibility of 'wheel deformity' investigated. At the same time the radiograms may afford some information in regard to the size of the empyema cavity. If it is apparent that the discharge is persisting in spite of conservative measures, further operation is indicated. The sinus area is exposed, a trap-door or omega incision being the best for the purpose; the track is fully opened up, and if any osseous deformity such as a 'wheel' is discovered, it is removed. By suitable retraction the interior of the cavity is exposed to inspection, any septic débris being removed.

If it is apparent that the walls of the cavity are so rigid that a natural expansion of the lung is impossible, it is necessary to carry out

such a sub periosteal rib resection that mobilization of the chest wall will result, and obliteration of the cavity thereafter proceed. What ever method may be used in this secondary operation free drainage is essential.

Tuberculous Empyema

Tuberculous empyema is a rare development, but it may arise in the following way. A pneumothorax develops secondary to pulmonary tuberculosis, and, as nearly all tuberculous cavities in the lungs are infected with streptococci, the eruption of such a vomica into the pleural cavity is almost of necessity followed by the development of an empyema. The infection, however, is of a mixed type, and it is scarcely correct to speak of it as a pure tuberculous lesion.

TREATMENT The treatment of such a case presents unusual difficulties. Thoracotomy and drainage are unlikely to be successful, in fact, they may be disastrous, because they permit of the introduction of a further infection. Experience has shown that the best results are obtained by the primary adoption of a thoracoplasty operation, which produces such an infalling of the chest wall that the underlying cavity is obliterated.

CHAPTER XXXI

DISEASES OF THE SPINE

PHYSIOLOGY AND ANATOMY

The Curves of the Spine. The orthograde attitude of the human spine has resulted in the acquisition of certain physiological curves. These are three in number—cervical (forward), dorsal (backward), and lumbar (forward). The dorsal curve may be regarded as primary in so far as it is present at birth, and at this stage it extends over a wider area than at a later period. About the sixth month the lumbar curve begins to make its appearance, but it is not definitely established until the child has begun to walk. The cervical curve is first apparent when the child begins to sit erect; it therefore appears about the fourth month.

A slight lateral curve convex to the right exists in most individuals. Its occurrence is so constant that it may be looked upon as physiological; it is usually ascribed to the pressure of the aorta on the vertebral bodies.

The Muscles of the Spine. The arrangement underlying the musculature of the spine is one of continuity from the head to the pelvis; the maintenance of the spine in the erect position by the muscles has been aptly compared to the support of a ship's mast by its stays.

No individual muscle extends from skull to pelvis, but the arrangement is such that, through the medium of intermediate fixed points of attachment, there is a continuity of muscular control. The principle is one of the most far-reaching importance in relation to spinal movements and to the maintenance of body balance, and the arrangement has to be constantly kept in mind where diseased conditions are concerned.

Intervertebral Arrangements. A typical thoracic vertebra has approximately ten points of articulation related to it in addition to the intervertebral disks—articulations with the related ribs, with the superior and inferior articular processes, and with the vertebræ above and below. This affords some indication of the complexity of the interosseous arrangements. A strong ligamentous union completes the intervertebral fixation. The anterior and posterior common ligaments bind the column together, the posterior ligament being further strengthened by the supra-spinous and interspinous ligaments, while

there are capsular ligaments round each articulation and intertransverse and interlaminar ligaments. Every spinal movement is therefore checked by several ligaments.

Movements of the Spine The most recent contribution to our knowledge on this subject indicates that the movements of the human spine are three in number—flexion or forward bending, hyperextension or backward bending, and a combined movement of side-bending and rotation. The idea that side bending and rotation existed as separate and independent movements has been disproved.

The movement of flexion exists in all the different regions of the spine, but it is least marked in the lumbar region, hyperextension is mainly confined to the lumbar and low dorsal regions, lateral bending is always accompanied by some degree of rotation, though one or other preponderates in individual movements. Side bending occurs in the region below the tenth dorsal spine, rotation is performed mainly in the dorsal and cervical regions.

Surface Anatomy The spinous process of the seventh cervical vertebra is usually the most prominent, in certain cases the first dorsal spine is more easily recognized. The upper border of the scapula is in a line with the second dorsal spine, the root of the scapular spine corresponds to the third dorsal spine, the lower angle of the scapula is on a level with the lower border of the seventh dorsal vertebra. The highest points of the iliac crests correspond to the upper border of the fourth lumbar vertebra, the third sacral is on a level with a line connecting the posterior superior spines of the ilium.

In estimating the situation of the bodies of individual vertebrae the fact must be borne in mind that in the dorsal region the obliquity of the spinous process is such that its tip corresponds to the centre of the body immediately beneath—in the lumbar region the spinous processes are opposite the corresponding bodies.

The spinal cord of the child extends to the lower border of the third lumbar vertebra.

CONGENITAL ANOMALIES OF THE SPINE

The Cervical Region The region of the cervical spine is peculiarly liable to be affected by various congenital errors. On the classification suggested by Bertolotti these may be arranged as follows—

1 *Ankylosis of the Atlas with the Occipital Bone* This error is a frequent associate of high spina bifida, it is often accompanied by defects in the basis cranii, asymmetry of the facial bones, and anomalies of the teeth. It would seem that the existence of the atlanto occipital ankylosis interferes to an unexpected extent with ossification, especially of the posterior part of the base of the skull.

2 *Assimilation of the third Cervical Vertebra and the Axis* This

anomaly results in the formation of a single bone possessing the morphological characters of a rudimentary axis ; the odontoid process may exist as an independent bone.

3. *Transverse Segmentation of the Vertebral Bodies.* This deformity is the result of the independent development of the two normal centres of ossification. It is always associated with congenital malformation of the soft tissues.

4. *Vertical Segmentation of the Bodies and Arches.* The segmentation affects the arches more frequently than the bodies, and varies from a slit to a wide gap (*spina bifida occulta*).

5. *Hemispondylia*, or the absence of one lateral half of a vertebra. The existing portion of the bone is usually ankylosed to the vertebra above and below.

6. *Cervical Ribs.* Mention has already been made of the existence of these structures in childhood. Their presence is sometimes associated with defective development of the lateral half of the corresponding vertebra.

CLINICAL FEATURES. It is impossible in a work of this description to enter into full detail regarding the various clinical evidences produced by the above-mentioned errors, but the evidences may be briefly summarized as follows :—

In severe types of deformity there is a reduction in the length of the neck so that the head is sunk between the shoulders, the occipital region of the skull is flattened, the scalp appears to descend to an unusually low level on the nape of the neck, the movements of the head are restricted, particularly those of flexion, the cranium is large and brachycephalic, the facial outline is asymmetrical, the upper part of the thorax is flattened and depressed anteriorly.

Minor types of anomaly such as hemispondylia of a single vertebra or atlanto-occipital ankylosis are distinguished by the existence of a torticollis and an angular deformity of the cervico-dorsal spine.

Dorsal Region. Anomalies of the *dorsal spine* are uncommon. Fusion of individual vertebræ is sometimes met with, and in cases of congenital scoliosis hemispondylia exists in one or more vertebræ.

Lumbar Region. In the *lumbar region* sacralization of the fifth lumbar vertebra is the most important type of anomaly. The transverse process may be so elongated and broadened that it comes into contact with the base of the sacrum, especially during lateral flexion of the spine. Sometimes the transverse process fuses with the base of the sacrum and even with the ilium so as to produce a complete unilateral or bilateral sacralization of the vertebra. While the anomaly may exist without giving rise to symptoms, it is sometimes the cause of pain in the regions of the hip and sacro-iliac joints, the result of pressure on the anterior division of the fifth lumbar nerve or the branch of the first sacral, which descends in front of the abnormal lumbo-sacral transverse articulation. Vertical segmentation of the lumbar arches occurs in association with spinal bifida.

SACRO-COCYGEAL TUMOURS AND APPENDAGES

Tail-like Appendages In the second month of embryonic life the tail of the human embryo contains rudiments of seven vertebrae, all but three of these disappear by absorption, leaving the associated tissue of the chorda dorsalis persisting for a considerably longer period of time. If for any reason the absorption of the superfluous elements miscarries, remnants of the tail persist and develop.

TREATMENT All tail like appendages should be removed at an early period of life, as they are apt to become serious embarrassments if allowed to remain.



FIG. 373.—Mixed Tumour of Sacral Region

A small mixed tumour growing from the sacral region. The clinical features closely resemble those of a spine bifida.

Tumours of the Sacro-coccygeal Region

A number of different tumours originate in the sacro coccygeal region. They may be classified as follows—



FIG. 374.—Sacral Teratoma (Baby 1½ years)

- A The sacro coccygeal tumours—teratomata
- B Sacral parasites
- C Dermoid cysts
- D Pre sacral and pre coccygeal cystic tumours of the post anal gut

A True Sacro-coccygeal Tumours These are usually present at birth, and it is interesting to notice that female children are most frequently affected. The size of the tumour is usually considerable; it is often half as large as the child. The smaller tumours are sessile, the large ones are pedunculated and pendulous, being attached by a narrow neck to the surface of the coccyx. The tumour is covered with

smooth natural skin; its consistency is firm, fluctuating in parts, where cysts probably exist. The general appearance is as though a cushion

were suspended between the child's legs, upon which it seems to sit.

When the tumour is incised it is found to be enclosed in a fibro-connective tissue capsule. Its actual structure is composed of a great variety of different tissues—connective tissue predominates; in addition there is a confused intermingling of fibrous or cartilaginous mucoid, nervous, osseous, and muscular elements. Cysts often exist; sometimes they are the result of necrotic softening, more frequently they are definite formations lined with stratified squamous epithelium or with columnar epithelial cells. Most of the cysts con-

tain mucoid material, some are filled with pultaceous debris resembling dermoid substance.

There is considerable contrast in the life history of individual cases—in some the tumour grows rapidly, in others it remains quiescent for many years. Under ordinary circumstances the tumour shows no signs of malignancy, though in a few cases a sarcomatous change has been reported. Certain sacro-coccygeal tumours are attached to the anterior surface of the sacrum, and enlarge forwards so as to fill the interior of the pelvis.

ETIOLOGY. The most recent view of the origin of these tumours is that they originate from the vestigial structures of the embryonal tail.

TREATMENT. In uncomplicated cases the results of operative treatment are excellent. The skin incision is made as far

FIG. 375.—Dermoid Tumour of mid-line of Back (Boy 9 years).

as possible from the anal orifice. Special care is given to hæmorrhage, as the tumour receives a profuse blood supply from the middle sacral artery. The closest attention is paid to asepsis, since infection of the wound may easily prove fatal.

B. Sacral Parasites. The sacral region is occasionally the site of embryonal parasites; in other words, it is supposed that the existing foetus had in the early stages of its development included the products of another fecundated ovum. Such tumours are usually recognized by inspection or dissection; they often contain developed formations such as a complete limb, portions of a skull, etc. Sometimes they are composed of a confused mass of tissues which cannot be distinguished from true sacro-coccygeal tumours.



C Dermoid Cysts These owe their origin to the cell inclusions which occur when the dorsal surface of the early embryonic mass unfolds itself. They are of the nature of sequestration dermoids, and they must be distinguished from the cystic mucoid tumours which originate from the post-anal gut.

D Pre-sacral and Pre-coccygeal Cystic Tumours In the early embryo the central canal of the spinal cord and the alimentary canal are continuous around the caudal extremity of the notochord. The segment by which these two structures communicate is known as the *neurenteric canal*.

When the proctodæum invaginates to form part of the cloacal



FIG 376.—Dermoid Tumour of Back (Baby 13 months old)

A large dermoid tumour of mid line of back. The centre is umbilicated and the overlying skin is the site of an extensive hæmangioma. The similarity to spina bifida is apparent.

recess it comes into contact with the gut at a point anterior to the spot where the neurenteric canal opens into it, hence there is for a time a segment of intestine extending behind the anus—this is the 'post anal gut'. Under ordinary conditions it disappears, but, if remnants of the structure persist, they are apt to develop into pre-sacral or pre-coccygeal cysts. The tumours exhibit a definite structure, they are composed of closed vesicles lined with glandular epithelium and containing mucous like fluid. Developing anterior to the sacrum, they enlarge and extend until they fill the true pelvis.

It is important to distinguish these tumours from anterior spina bifida, an X ray examination should make the distinction clear.

TREATMENT Incision and enucleation of the cyst wall is the only efficient treatment. Access is gained by an incision which runs lateral to the sacrum and coccyx.

SPINA BIFIDA

The subject of spina bifida has an important place in pediatric surgery because the deformity is estimated to occur once in every thousand births. The error is a very distressing one—the mortality is

high, about 80 per cent. of the cases dying in the first year of life. There are often associated changes of the neuro-muscular system, which, even if the child survives, render it wholly or partially incapacitated.

Of the various congenital abnormalities which involve the spinal cord, spina bifida is the only one of real clinical importance. Such grave defects as *amyelia*, *atromyelia* and *diplomylia* are either incompatible with life or are associated with such grave concomitant errors that life persists for only a few hours or days, while, at the opposite



FIG. 377.—A large Myelo-meningocele of the Dorso-lumbar Region. There is extensive deformity of both lower limbs, the result of the involvement of nerve tissue in the sac.

extreme, such slight abnormalities as *asymmetry* and *heterotrophy* are of no clinical significance, because they give rise to no functional disturbance. Spina bifida, however, standing in an intermediate class, with its wide differences of type, and in many cases with possibilities of cure, demands the close attention of the surgeon.

TERMINOLOGY. The term spina bifida was introduced by Tulp in the middle of the seventeenth century, and, though other descriptive terms have been suggested from time to time, such as *hydrorastis* and *rachischisis*, spina bifida is the terminology most commonly adopted.

Etymologically, the term is derived from the Latin, and means a cleft in the spinal column. The term *rachischisis* is now used to denote a congenital error akin to spina bifida, in which there is a complete non-union of the walls of the medullary canal, and the qualifications *complete* or *partial* are used to denote the extent of the deformity.

This error, however, is always extensive it is accompanied by such grave defects as anencephaly or *acrima*, and as the repair of the defect is impossible, it does not concern the surgeon

DEFINITION *Spina bifida* may be defined as a congenital defect in the vertebral column through which there is a protrusion of the contents of the vertebral canal, the protrusion is usually in the form of a cystic tumour containing cerebro spinal fluid

VARIETIES The skeletal defect ordinarily involves the spine and the laminae, therefore the projection is posterior, and the condition is a *posterior spina bifida*. In rare instances the defect affects the bodies of the vertebrae and the protrusion is into the pelvis, the abdomen or the thorax—*anterior spina bifida*. The walls of the projecting sac may be composed of one or all of the membranes being the condition known as a *spinal meningocele*, or cord and roots may be combined with the membrane in the sac wall, the cerebro spinal fluid being in the sub dural or sub arachnoid space—the *meningo-myelocoele*—or the membrane and cord may protrude through the defect, the collection of fluid being in the dilated central canal of the spinal cord—*syringo-myelocoele*. Again, the development of the posterior part of both spinal cord and spinal column may be grossly deficient, because the medullary ridges have failed to unite over a localized area the result being an open groove in the back which communicates with the central canal of the spinal cord and which is described as a *myelocoele* or, more accurately, as a *partial rachischisis*. It may happen that the congenital defect merely involves the formation of the spinal column, with only minor secondary errors in the meninges, and the error is then described as a *spina bifida occulta*.

AGE AND SEX INCIDENCE *Spina bifida* being a congenital error, it is present from the moment of birth though in certain cases of *spina bifida occulta* the actual protrusion of the sac through the deficient spinal column may not appear until some years have elapsed

It is sometimes stated that the condition is slightly commoner in females than in males, but our experience in the analysis of 200 cases has been that the sex distribution is practically equal

PATHOLOGY

Before a proper appreciation of the pathology can be obtained, it is essential to have a knowledge of the method by which the spinal cord and the spinal column are formed and developed

The Embryology of the Spinal Cord and Spinal Column The situation of the spinal cord is first indicated by a shallow groove of the epiblastic layer in the entire length of the dorsal surface of the embryo. That portion of the epithelium which forms the floor of the groove is known as the 'medullary plate'. At the edges of the groove there is a heaping up of the epithelium to form the medullary ridges the summits of the ridges ultimately uniting to form a tube lined with epithelium the 'neural tube'. This tube eventually becomes detached from the overlying epiblast from which it was originally derived

the projection of the mesoblast between the neural tube and over-

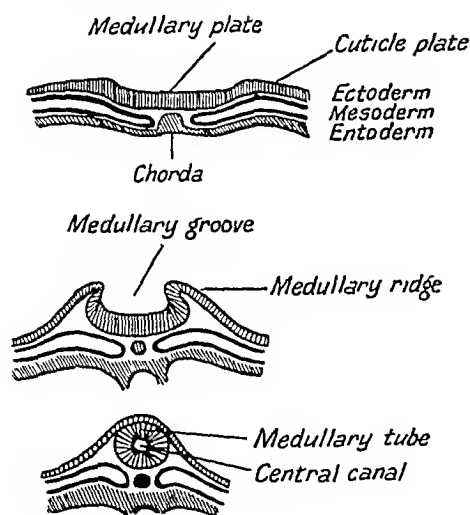


FIG. 378.—The Method of Formation of the Neural Tube. (After Villiger.)

lying epiblast being the influence which effects the separation. The neural tube, or the medullary tube (as it is sometimes called), forms the spinal cord, while the mesoblast which surrounds it becomes gradually transformed into the meninges, the vertebræ, the muscles, and the associated ligaments. Each vertebra has three centres of ossification—one for the body, and one for each half of the neural arch, the latter being formed by the fusion posteriorly in the median line of the two laminæ arising from the separate centres of ossification. The union of the lateral laminæ

to form the spine begins in the thoracic region, and extends both caudally and cephalically along the length of the embryo. If the formation of the spinal cord and the spinal column is to be perfect, two processes must be completed—the separation of the neural tube from the overlying epiblast by the influence of the mesoblast, and the union of the laminæ in the median posterior line to complete the formation of the spine. It would seem that the pathogenesis of spina bifida largely depends upon the failure of these two processes to become complete

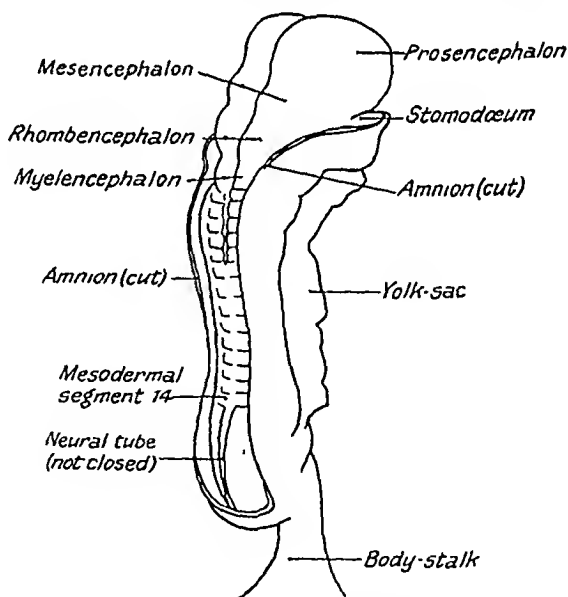


FIG. 379 —The Formation and Closure of the Neural Tube (After Kollmann.)

PATHOLOGICAL ANATOMY

We have described five different varieties of spina bifida, in each of which the pathology differs. The varieties are: (1) *spinal meningo-*

cele, (2) *Myelo meningocele*, (3) *Syringo myelocele* (myelo cystocele), (4) *Myelocele* or *partial rachischisis*, and (5) *spina bifida occulta*. There is one defect common to all varieties, namely, the imperfect formation of the laminae of the spinal column in the area in which the spina bifida occurs, and associated with the imperfection of the laminae there is necessarily absence of the spinous processes, but in the relationships of the spinal tumours the characteristics vary.

(1) **Spinal Meningocele** The pathology of this type may be described as follows. Through the congenital defect in the posterior wall of the spinal column, there is a saccular protrusion of the dura mater, the cavity is filled with cerebro spinal fluid, but there is an entire absence of nerve tissue in the sac. The sac is continuous with the spinal meninges through a comparatively narrow neck, and is covered with healthy skin, which as a rule is free from any direct attachment to the sac except at the fundus.

(2) **The Myelo-meningocele** In this variety, the error in the posterior wall of the spinal column is usually an extensive one, involving the laminae of three or four vertebrae. Through this defect there is a saccular projection more often sessile than pedunculated. If the sac wall



FIG 380 — A large cervical Spina bifida of the Meningocele Type

The fundus of the tumour is covered with hemangiomatous tissue. No paralytic lesion accompanied the deformity.

is traced around its circumference, different constituents are found to compose it—dura mater forms that portion next the spinal cord the dura gradually merges into a true epithelial lining, serous like in its characters, and probably derived from the pia and this in turn blends with an area of vascular nerve tissue, which occupies the middle line and therefore forms the fundus of the sac. If the sac is viewed from the surface, an impression is got of certain of the various constituents—on the fundus of the sac the area of granulation tissue is recognizable around this there is the thin pellicle of serous like tissue, while still farther out the skin is recognizable though altered by being thickened and often affected with telangiectasis or hyper

trichosis. According to Von Recklinghausen's description, the different appearances of the exterior of the myelo-meningocele are given the respective names of the *area medullo-vasculosa*, the *zona epithelio-serosa*, and the *zona dermatosa*. The sac contains cerebro-spinal fluid and nerve tissue, and it will be noticed that the nerve tissue

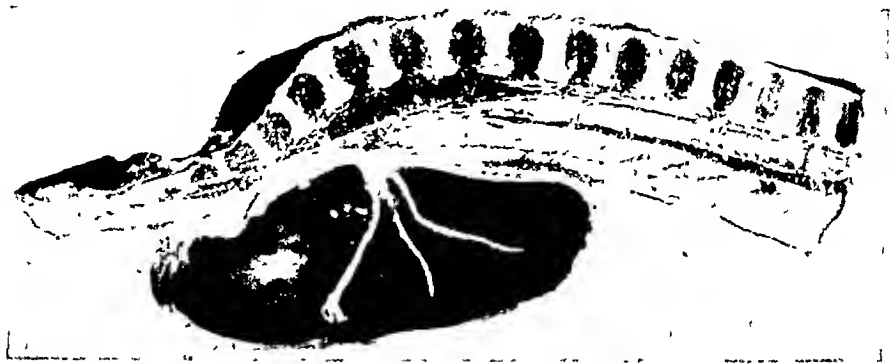


FIG. 381.—A Myelo-meningocele of the Lumbo-sacral Region.

Three nerve roots springing from the remains of the cord on the convexity of the sac are returning across the sac to the vertebral canal.

always has its peripheral attachment to the area vasculosa of the sac. The nerve tissue which the sac contains varies according to the position in which the spina bifida occurs ; at a high level the spinal cord may traverse the sac, become merged into the area vasculosa, and then leave the sac to enter the spinal cord lower down ; at a lower level the

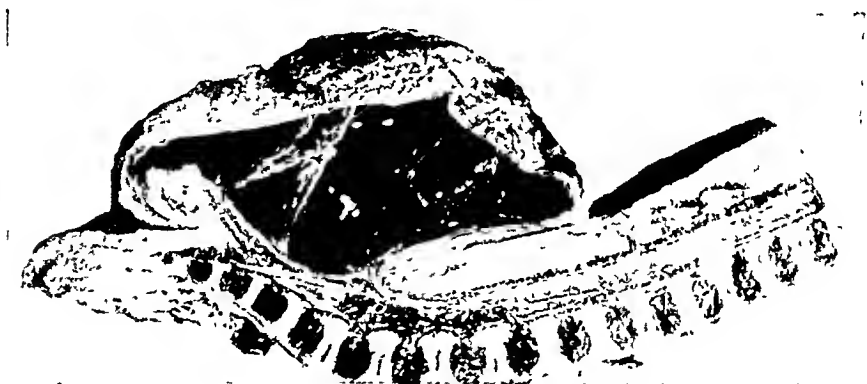


FIG. 382 —The appearance on Section of a Lumbo-sacral Myelo-meningocele.

spinal cord may seem to end in the area vasculosa, and from this point strands of the cauda equina may traverse the sac to attach themselves and to disappear in the area vasculosa. It frequently happens that the sac is traversed by intra-thecal portions of the related spinal nerves. The relationship of these is often confusing to the student, but the diagrammatic representation attached should make the position

clear (Fig 386) The nerve roots spring from the area vasculosa, and with care it is sometimes possible to demonstrate the anterior and posterior divisions of each They then pass forwards across the sac cavity to enter the spinal canal, and eventually leave it through the inter vertebral foramina

From what we have described it should be apparent that the area vasculosa is none other than an undifferentiated portion of the spinal cord, and that the cerebro spinal fluid in the sac of the myelomeningocele is actually collected on the ventral surface of the spinal cord

(3) The Syringo-myelocoele or Myelo-cystocoele In this, in common with the other types, the laminae are defective, and the spines absent over the area involved in the defect On the surface there is a somewhat elongated, cyst like swelling The skin which covers the sac is well formed and uniform, it is often pigmented and covered with a thick growth of hair When the sac is opened there is found to be a partial lining of imperfect dura mater, with a pial lining on the fundus closely adherent to skin and within this there lies the spinal cord, so thinned out by distention of the central canal that it would seem in places as though it formed a portion of the lining of the sac wall While a certain amount of cerebro spinal fluid is present in the arachnoid spaces around the cord, the bulk of the fluid is accumulated in the much dilated central canal

In many cases the spinal cord has escaped entirely from the confines of the canal of the spinal column, though it is often possible to replace it by pressure The cord may be so compressed that in places it is scarcely recognizable, and the nerve roots are stretched

(4) Myelocoele or Partial Rachischisis If the interference with development is so great that the edges of the medullary groove have failed to unite over a certain area, the result is the formation of a myelocoele This deformity is most common in the lumbar region, because it is in this area that the normal closure is most delayed The defect appears on the surface as an elongated fissure, the edges being scarred and irregular, frequently covered with telangiectasis,

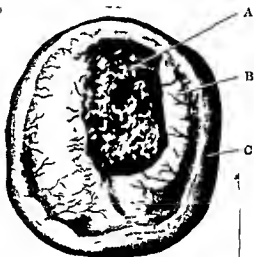


FIG 383—The various Zones of a Myelo meningocele (After Bockenheimer)

A Area Medullo-vasculosa B Zona Epithelio-aerosa C Zona dermatosa

and sometimes a growth of hair surrounds the cleft. From the cleft, cerebro-spinal fluid escapes, and, if a probe is inserted into the cavity, it will be found to pass into the central canal of the spinal cord. The floor of the cleft is formed of a vascular nerve tissue, which in fact is none other than the posterior surface of the anterior column of the spinal cord.

The condition is rarely compatible with post-natal life ; the mother is frequently affected by hydramnios and the child shows anencephaly and other grave developmental defects. The condition is never amenable to surgical treatment.

(5) **Spina Bifida Occulta.** In spina bifida occulta the development of the spinal cord is complete and the epidermis is closed. There is a spino-laminal defect in one or more of the vertebræ, but the



FIG. 384.—Lumbar Spina bifida of the Myelocoele Type (Baby 10 days old).

hermal protrusion characteristic of the other types of spina bifida is either absent or is so small as to pass unnoticed. The skin and spinal cord, however, have never become completely separated, and a firm band of fibrous tissue (the *membrana reuniens*) passes from the underlying dura through the vertebral defect and connects the cord with the overlying skin. On the surface of the body the most conspicuous change is the overgrowth of hair (hypertrichosis) which marks the area of the superficial attachment of the *membrana reuniens*. In this situation there may be an indentation of the skin, the *fossa coccygea*, and sometimes cicatricial changes, telangiectasis or pigmentation mark the situation overlying the defect. In many cases the *membrana reuniens* entirely fills the vertebral cleft, and there may be associated tumours inside or outside the vertebral canal, such as lipomata, angiomatica, and dermoid cysts.

The clinical importance of *spina bifida occulta* is that the *membrana reuniens* does not increase in size proportionately to the growth of the spinal cord and column, so that a time comes (usually about the tenth or twelfth year) when there is compression of the cord and roots resulting in the development of paralysis—motor, sensory and trophic disturbance, and even paralysis of the bladder and rectum

Anterior Spina Bifida

In certain rare cases there is a defect of the bodies of the vertebrae, so that the contents of the spinal canal extend into the pelvis, abdomen, or thorax, simulating a visceral tumour. The error is most frequent in the sacral region, so that the tumour gravitates into the pelvis. As in the posterior tumour, the walls of the sac are



FIG. 385.—*Spina bifida occulta* of the Lumbo sacral Region (Child 4 months)

composed of one or all of the spinal meninges, and the sac contains a large amount of cerebro spinal fluid, but it is uncommon to find any nerve tissue in the sac. The anomaly is an exceedingly rare one—we have met with only one example of it, in which the large cystic tumour occupied the pelvis of a female child and gave rise to a chronic intestinal obstruction.

THE ETIOLOGY OF SPINA BIFIDA

It is apparent that a *spina bifida* develops because of an anomaly in the formation of the spinal nervous system, and, coming to more exact details of embryology, it would seem that it is in the arrangement of the mesoblast that the actual error occurs. If the mesoblast forms an imperfect layer on the dorsal surface of the medullary tube there will be an incomplete separation between the medullary tube (spinal cord) and the overlying epiblast (skin), with the result that the laminae are

imperfectly formed, the vertebral spines are absent, and according to the extent of the error in separation, various degrees of spina bifida result. At one end of the scale separation has been almost complete, but the membrana reuniens persists, and a spina bifida occulta results ;

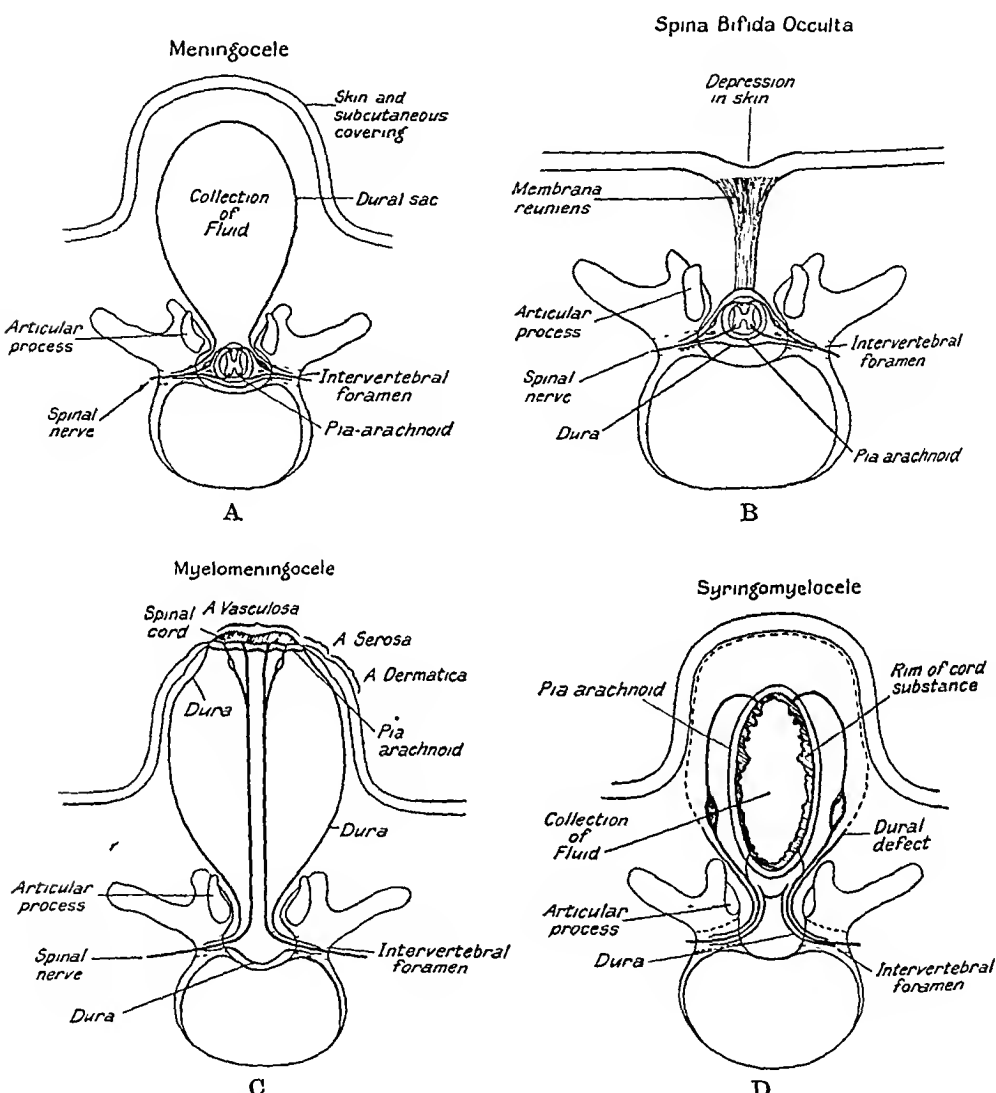


FIG. 386 —Diagrammatic Representation of the anatomical Relations of the various Types of Spina bifida. (After Frazier.)

A. Meningocele. B Spina bifida occulta. C Myelo-meningocele. D. Syringo-mycelocele.

at the other extreme there is the myelocele (partial rachischisis), where there has been no attempt at separation of the medullary plate to form the medullary tube, and the edges of the neural groove remain open. The other varieties of spina bifida depend on variations of the common error, with a superadded influence that irritative changes

arise which result in the accumulation of fluid in the sub arachnoid space or in the central canal of the spinal cord

The enquirer will probably ask whether there is any theory which will explain the primary developmental error which we have described. No reliable information is available, though many theories have been put forward. In 1893 Hertwig discovered that spina bifida may be produced in tadpoles by treating the ova of frogs with common salt, and other experiments have produced anencephaly and cyclopia in the embryos of fish and amphibia, so that there is some evidence to correlate the origin of spina bifida with external influences. It is said that studies of the human embryo suggest a connection between spina bifida and uterine disease, the toxins of the latter affecting the embryo. There is in fact a tendency at present to revert to the older view of a primary localized dropsy of the foetus, the dropsy being the result of a local irritation set up by toxins derived from the mother or of a weakening of the foetal heart muscle secondary to a toxæmia. The local accumulation of fluid is thus regarded as checking the development of the meso-elastic layer, and as causing atrophy by pressure.



FIG. 387 — Large Lumbosacral Myelomeningocele

Note the deformity of the lower limbs, the result of the imperfect development of the fibres of the cauda equina

THE CLINICAL FEATURES

The clinical features may be said to fall into three groups —

- (1) The local signs due to the presence of the spinal condition
- (2) The nervous signs which result from pressure upon or degeneration of the spinal cord, the cauda equina, or the nerve roots
- (3) The signs of associated malformations and defects

(1) The Local Signs

These have been partly alluded to in connection with the pathology. The meningocele, the myelomeningocele, and the myelo-cystocele show the presence of a hernial protrusion in the bony of the spine. As the hernia contains cerebro spinal fluid, and is in direct communication

with the general sub-arachnoid spaces, it is of variable volume and size and is increased by the erect position and by expiratory acts such as crying. It is yielding and fluctuating—continued pressure may diminish its contents by replacing the fluid within the vertebral canal, but the manœuvre is dangerous, because the increased pressure may cause convulsions. The tumour is often transparent to strong illumination. Much information can be obtained by O₂ injection and X-ray, and this is discussed more fully later.

The appearances of the spina bifida occulta and the myelocoele have been described.

(2) *The Nervous Signs.*

Nervous phenomena depend upon the degree to which the nerve elements are involved in the defect; they are therefore absent or slight in the meningocele, they may become apparent in the spina



FIG. 388 —Lumbar Spina bifida of the Myelo-meningocele Type.

The right leg shows the talipes deformity which so often accompanies the spinal error.

bifida occulta, while they play an important part in the syndrome of the other varieties. There are motor, sensory, and trophic disturbances, which vary according to the situation of the lesion, and the degree of involvement of the nerve elements.

The motor roots and tracts suffer most severely; there may be complete paraplegia with secondary contraction and muscular wasting, and in an extensive lesion the musculature of the bladder and rectum is usually involved. Sometimes the paralysis is limited to a single limb or to a special group of muscles, and talipes may then result. If the spina bifida occurs in the cervical or upper dorsal region the paralysis may be a spastic one.

Sensory changes are invariably present if a motor lesion exists, but the demonstration of this error in the child may be impossible. The areas of sensory disturbance are usually extensive, and limited to the lower limbs.

Trophic disturbances may be manifested in decubitus, leioderma, and perforating ulcer.

(3) *Associated Malformations*

The vertebral column is often malformed in association with spina bifida apart from the spino laminal defect. The number of vertebræ may be diminished, or certain of them may be malformed, so that congenital scoliosis or kyphosis results.

It sometimes happens that two varieties of spina bifida occur in the same individual. Hydrocephalus is often associated with spina bifida.

A great variety of associated defects have been met with in other parts of the body, such as absence of patella, congenital dislocation of the hip and extroversion of the bladder.

X ray Investigation By the injection of O₂ into the sac of the tumour and subsequent X ray examination of the part, precise information of the presence or absence of nerve contents, of the nature of the contents when present, and of the exact position of their peripheral attachments can often be obtained. The method has proved of enormous value.

Technique Under anaesthesia, the sac is perforated with a hollow needle through healthy skin, and cerebro spinal fluid is drawn off in an amount which varies with the size of the sac—40 to 50 c.c. of fluid is an average quantity. In order to prevent trouble from the sudden relief of pressure, the fluid is removed in quantities of 10 c.c. at a time, and each evacuation of 10 c.c. is replaced by a corresponding amount of O₂. When O₂ has been introduced in an amount equal to the total fluid removed a series of radiograms is taken in lateral and antero-posterior positions. The method is especially useful in the investigation of the myelo-meningocele type of spina bifida for the localization of the nerve elements facilitates the planning of subsequent operative interference.

DIAGNOSIS

In the majority of cases, the nature of the error is self-evident—the congenital hernial protrusion, the defect in the posterior part of the spinal column, and the characteristic X ray appearance are sufficiently distinctive of the condition. Difficulty may arise in the recognition of the spina bifida occulta, but the hypertrichosis, the pigmentation, and the presence of the fossa coccygea admit of but one interpretation. The greatest diagnostic difficulty arises in connection with the anterior spina bifida. The condition is generally mistaken for a pelvic or abdominal tumour, and often it is only at operation that its true nature is revealed. A careful X ray examination is of great value.

The diagnosis will include the differentiation between the three varieties of cystic posterior spina bifida. The arrangement of a triple surface zone is characteristic of the myelo-meningocele, but

real difficulty occurs in distinguishing between the meningocele and the myelo-cystocele. In the O_2 and X-ray method of investigation we have a means of distinguishing with complete certainty between the various types.

The Differential Diagnosis. It is conceivable that swellings over the spine which have no connection with the spinal cord or its membrane may be mistaken for spina bifida; the examiner must



FIG. 389.—Oxygen Radiogram of Lumbar Spina bifida of the Myelo-meningocele Type (Baby 2½ months).

therefore take care to exclude such conditions as post-rectal dermoids, sacro-coccygeal teratomata, lipomata, angiomata, and ischiatic herniæ.

TREATMENT

At the present time it would seem that operative closure of the sac is the only line of treatment which is considered, but it is well to remember that in the past many satisfactory results have been recorded from such procedures as injection of iodine solution or snaring off of the sac. Perhaps we under-estimate the value of these

methods, and, in view of the difficulties, the restrictions and the risks which are attendant upon operative closure, it may well be that in the future we shall see the resuscitation of older methods in the treatment of spina bifida. As things are at present, however, open operation is the only line of treatment which is seriously considered.

Conditions favourable for Operation A careful judgment must be exercised in deciding upon the type of case which is suitable for operation, and the following points are taken into consideration —

(1) *The Age of the Child* It is our practice to advise operation at some period between the third and the fifth month. Such a recommendation is dependent, of course, upon other conditions being favourable, but we have found that at this age the operation is as well tolerated as it is at a later date, while the early operation may save the life of a child in which the spina bifida would later become infected.

(2) *The Type of the Spina Bifida* The pure meningocele is the most suitable for operation, myelocystoceles are somewhat less promising, myelo meningoceles are definitely unpromising, while the myelocoele type is quite unsuitable for operative interference. By the method of O₂ injection and X ray examination we are able to classify each case with certainty.

(3) *The Condition of the Tumour Wall* A leakage of cerebro spinal fluid or any infected area or ulcer of the sac surface should be accepted as contra indications to operation. Even a small ulcer, which from its extent would seem to be capable of sterilization, is likely to be surrounded by infected lymphatics, and these originate a meningitis which is invariably fatal. It is this objection which is so strong in the case of the myelo meningocele for the condition of the area vasculosa is almost invariably one of infection. A sac which is covered with healthy skin is the strongest guarantee of successful operation.

(4) *The Co existence of Paralysis* An extensive paralysis of the lower limbs and especially paralysis involving the rectum and bladder should be accepted as contra indicating operation. On the other hand,



FIG. 399.—A Naevoid Tumour of the Mid line of the Back which simulated a Spina bifida.

a unilateral talipes or even a more extensive involvement if confined to one limb, should not exclude operation.

(5) *The General Condition of the Child.* The general health of the child should be good before operation is countenanced; any rise of temperature or any intercurrent illness, however slight, should be taken as indicating the postponement of the operation until the conditions are favourable.

(6) *Hydrocephalus.* The development of a hydrocephalus in an infant already the victim of spina bifida should be accepted as an absolute contra-indication to operation. While the operative closure may at first be successful as far as the spinal condition is concerned, after a period of time the hydrocephalus progresses and the increasing pressure of cerebro-spinal fluid may result in a recurrence of the cystic tumour at the site of the spinal defect.



FIG. 391.—Large Myelo-meningocele of the Dorsal Region.
The *arca medullo-vascularis* is well seen.

Conservative Treatment before Operation. The conservative treatment consists in maintaining the wall of the spina bifida in as healthy a condition as possible. Infection of the skin, ulceration of the coverings, leakage of the contents have all to be guarded against, because they so invariably end in a fatal meningitis. We advise therefore that the surface of the tumour be treated each day with absolute alcohol, that a protective covering in the shape of a 'nest' of cotton-wool be provided, and that the mother be advised to nurse the child as far as possible on its face. A careful watch is kept upon the degree of tension of the contents, for a persistent high tension may result in spontaneous rupture of the wall, with an early fatal result. To prevent this the fluid should be aspirated in small quantities from time to time, care being taken that the needle is inserted through healthy skin at some distance from the summit of the tumour.

The Operation. The ideals of the operation are to excise the sac,

to reduce its contents or to remove them if irreducible, to shut off any communication of the sub dural space with the exterior, and to repair as far as is possible the musculo osseous defect of the back

Technique The child is placed on its face with the head at a lower level than the trunk. All reasonable precautions are taken to guard against shock, and against cooling of the body surface, and the operation must be carried out with the least possible amount of bleeding. If there are any areas of the tumour wall which may be infected, these are sterilized, as far as is possible, by the application of the actual cautery or by pure carbolic

Incision An incision is planned so that when the edges are united a strong suture line is provided which completely shuts off the line of approximation of the deeper tissues. In the meningocele and myelo cystocele types the ideal is best obtained by a trapdoor or omega shaped incision, in the myelo meningocele type a transverse incision is the most suitable

Isolation of the Sac By careful sharp dissection the inner wall of the sac is defined, and an attempt is made to isolate a pedicle of it

close to the laminal defect. The greatest care is required to prevent puncturing the sac wall at its neck, because in this situation it adheres closely to the edges of the laminae, and yet separation from the laminae is necessary, because the object is to replace the closed pedicle within the vertebral canal

Opening the sac The sac is now opened to one side of the midline. It is at this stage that the information afforded by X ray is valuable, because it enables us to determine the exact position and attachment of nerve contents, if such are present

The procedure will now vary according to the type of the spina bifida. In the meningocele, if the sac is found to be free from nerve roots, the redundant portion of the sac is excised, and closure effected



FIG 392 —Upper Dorsal Spina bifida of the Meningocele Type

The tumour is pedunculated and no nerve elements are present in the sac

by a continuous suture of fine silk or linen thread : if roots are present and unattached they are replaced within the canal ; if the roots are attached to the sac they are either separated at the point of attachment to the sac wall and restored to the canal, or they are divided opposite the neck of the sac and removed with the latter. In the division of a nerve root lying within the sac it is important to recognize the fact that a blood-vessel always accompanies the root, and that ligature is necessary after division—failure to observe this precaution has resulted in fatal intra-thecal hæmorrhage.

In the myelo-cystocele type the chief difficulties arise in connection with the separation of the skin from the sac wall and the disposition of the cyst and the cord. Careful dissection with a sharp knife will overcome the first difficulty. If the cyst is small it may be replaced intact, but, if too large to permit of this, it should first be tapped and then replaced. If the dimension of the sac be such that replacement is obviously impossible, a sufficient portion of its wall should be removed to permit replacement of the cord, and to do so it may be necessary to tap the fluid in the dilated central canal.

In the myelo-meningocele type the most important feature of the operation is the preservation of the area medullo-vasculosa—this must be retained, because it contains the ganglion cells.

The sac is opened to one side of the mid-line. If the nerve roots are free, lateral portions of the redundant sac are removed, and the nerve roots with the area medullo-vasculosa are returned to the cavity of the vertebral canal ; if the nerve roots are adherent to the sac wall it is best to aspirate the sac and to replace it *in toto*.

Repair of the Musculo-osseous Defect. The first barrier to ensure closure of the defect is the dura, and in several respects it is the most important ; the edges are united with a continuous suture of fine silk or linen thread. The closure of the gap in the vertebral column can be effected in a variety of ways—musculo-fascial flaps may be turned inwards so as to meet in the middle line, auto-plastic transplantation of fascial flaps may be used, the bases of the vertebral arches may be fractured so as to permit the approximation of lateral osseo-muscular flaps in the middle line, autogeneous transplantations of bone may be arranged so as to bridge the defect, or foreign substances such as silver or celluloid may be used to fill the gap. In our own practice we have confined ourselves to two methods—if the defect is a small one we repair it by musculo-fascial flaps ; if it is a more extensive one we divide the vertebral arches, and so provide a strong osseo-muscular barrier. More superficially a fascial closure is arranged, and the skin edges are finally united with a broad surface of closure.

AFTER-TREATMENT. After operation the child is nursed upon its face for a period of ten days until healing is firm. Urotropine is administered as a routine for some days before and for a week after the operation, but it is impossible to state whether this administration is of any real value.

The Treatment of Spina Bifida Occulta No treatment is indicated unless pain or signs of pressure upon the cord or nerve roots are becoming apparent. It is usually about the tenth year before such signs appear, and operation is then demanded.

The operation is a simple one. The centre of the area of hypertrichosis or the depression of the fossa coccygea are taken as indicating superficially the peripheral attachment of the membrana reunions. The area is included in an elliptical incision, reflection of the skin edges will expose the fibrous outline of the membrane, and this is folded downwards between the muscles of the back until it disappears through the spinolaminar defect. A sufficiency of bone is removed around the defect to expose the underlying cord, and the deep attachment of the membrane will now be recognized stretching across the vertebral canal, it may be possible to demonstrate the compression of cord or roots which has resulted from the pressure of the band. The band is carefully dissected upon a director, and the operation is concluded by closure of the tract which was formerly occupied by the membrana reunions.

ROUND SHOULDERS

The surgeon is often consulted in connection with the treatment of the postural error of the spine which is conveniently described as 'round shoulders'. It is an unsightly deformity associated with ungainly attitude and gait, and, if untreated, is likely to become complicated sooner or later by debility, imperfect development, and neurasthenia.

VARIETIES OF THE ERROR

Lovett, who has written largely on this subject, suggests the recognition of four different types of the error —

Type I The round back, in which there is a persistence of the general spinal kyphosis of infancy shared by dorsal and lumbar spine alike.

Type II The hollow round back, in which a kyphosis of the dorsal spine is associated with, and to some extent compensated by, an increase of lordosis in the lumbar spine.

Type III The round upper back, in which the backward curve occurs in the upper part of the dorsal spine, the lumbar physiological curve remaining unaltered. This variety is most likely to be associated with forward displacement of the head and exaggerated tilting of the scapulae.

Type IV The flat back, in which a vertebral column of unusual straightness is associated with a forward rounded position of the shoulders.

by a continuous suture of fine silk or linen thread : if roots are present and unattached they are replaced within the canal; if the roots are attached to the sac they are either separated at the point of attachment to the sac wall and restored to the canal, or they are divided opposite the neck of the sac and removed with the latter. In the division of a nerve root lying within the sac it is important to recognize the fact that a blood-vessel always accompanies the root, and that ligature is necessary after division—failure to observe this precaution has resulted in fatal intra-theccal hæmorrhage.

In the myelo-cystocele type the chief difficulties arise in connection with the separation of the skin from the sac wall and the disposition of the cyst and the cord. Careful dissection with a sharp knife will overcome the first difficulty. If the cyst is small it may be replaced intact, but, if too large to permit of this, it should first be tapped and then replaced. If the dimension of the sac be such that replacement is obviously impossible, a sufficient portion of its wall should be removed to permit replacement of the cord, and to do so it may be necessary to tap the fluid in the dilated central canal.

In the myelo-meningocele type the most important feature of the operation is the preservation of the area medullo-vasculosa—this must be retained, because it contains the ganglion cells.

The sac is opened to one side of the mid-line. If the nerve roots are free, lateral portions of the redundant sac are removed, and the nerve roots with the area medullo-vasculosa are returned to the cavity of the vertebral canal; if the nerve roots are adherent to the sac wall it is best to aspirate the sac and to replace it *in toto*.

Repair of the Musculo-osseous Defect. The first barrier to ensure closure of the defect is the dura, and in several respects it is the most important; the edges are united with a continuous suture of fine silk or linen thread. The closure of the gap in the vertebral column can be effected in a variety of ways—musculo-fascial flaps may be turned inwards so as to meet in the middle line, auto-plastic transplantation of fascial flaps may be used, the bases of the vertebral arches may be fractured so as to permit the approximation of lateral osseo-muscular flaps in the middle line, autogeneous transplantations of bone may be arranged so as to bridge the defect, or foreign substances such as silver or celluloid may be used to fill the gap. In our own practice we have confined ourselves to two methods—if the defect is a small one we repair it by musculo-fascial flaps, if it is a more extensive one we divide the vertebral arches, and so provide a strong osseo-muscular barrier. More superficially a fascial closure is arranged, and the skin edges are finally united with a broad surface of closure.

AFTER-TREATMENT. After operation the child is nursed upon its face for a period of ten days until healing is firm. Urotropine is administered as a routine for some days before and for a week after the operation, but it is impossible to state whether this administration is of any real value.

Round shoulders may be said to be distinguished by absence of pain, a deformity of gradual outline, no great degree of stiffness, and normal X ray appearances

PROGNOSIS

The question of prognosis centres round the period at which treatment is begun in early flexible cases a complete cure will result if proper treatment is ensured. On the other hand, if the condition is neglected, and the child is allowed to grow with a flexed spine, adaptive changes occur which ultimately become irremediable

TREATMENT

The principle holds good here, as it does in so many static errors, that, before proper remedial treatment can be carried out, the part must be in a thoroughly flexible condition. It is obvious, therefore that treatment will vary according to the condition of the spinal column—whether it is flexible, resistant, or rigid

Treatment of the Flexible Type The general conditions of the child's life are brought under review. Sufficient rest is arranged for, errors of position are corrected, the clothing is arranged so that no undue strain is put upon the shoulder girdle, general hygiene is regulated, and the food question is revised

The actual corrective treatment of the deformity consists in the employment of exercises designed to strengthen the muscles of the back, abdomen and scapular region

Lovett recommends two types of exercise in this connection —

(1) *Back Exercise* 'The patient stands and bends the body forward at the hips and flings the arms forwards and upwards with the elbows straight. A deep breath is taken as the arms are flung forwards, and it is important that the back be kept straight as the bending position is assumed'

(2) *Abdominal Exercises* 'The patient lies on his back and comes up to a sitting position with the hands behind the neck'

Treatment of the Resistant Type The ideal here is to restore flexibility to the part, and thereafter to continue on the lines recommended for the flexible type

Flexibility is restored by careful stretching of the part. This is done while the child lies on its back with a rounded firm pillow under the prominent portions of the spine. The spinal column is stretched and straightened, the shoulders are bent back so as to stretch the shortened thoraco humeral muscles while the spine is rendered as mobile as possible by massage, manipulation and exercises. When a satisfactory degree of flexibility has been secured the case is treated upon the lines suggested for the flexible type

Treatment of the Rigid Type Before any case is placed in this category an effort should be made to lessen the disability by the

ETIOLOGY

The error may become evident at any period from the time the erect position is assumed by the child until adolescence. Its origin in certain cases is a congenital one, and there is reason to suppose that the Round Back Type I is a persistence of the physiological curve of early infantile life.

Postural errors at school or at work, particularly when acting on a debilitated child, are the most fertile sources of the acquired types of the disorder. The wearing of heavy clothing which is suspended by shoulder bands so that the shoulder girdle and upper dorsal spine ultimately support the weight is an influence of some etiological importance, and rickets or any of the various diseases associated with errors in ossification exert a certain predisposing influence.

PATHOLOGY

In its early phases the disorder is an exaggeration of the physiological backward curve of the dorsal spine. By position and manipulation it is possible to correct the error, and therefore it is convenient to classify the early stages as '*flexible*' in type. As time goes on, if the condition is neglected, adaptive shortening changes appear in the related muscles, particularly in the thoraco-humeral and thoraco-scapular groups; in that event considerable difficulty is experienced in the correction of the deformity, and we therefore speak of it as being '*resistant*' in type. At a still later period the bones and ligaments of the spine become altered (especially the former), in keeping with Wolff's law, so that osseous and ligamentous changes in the bones of the spine fix the parts to such an extent that the error may be described as '*rigid*' in type.

PHYSICAL SIGNS

The attitude is a distinctive one. The head is carried forwards and the neck is slightly flexed, the dorsal region is unduly prominent, and an unusual degree of lumbar lordosis may exist. The chest is flat and narrow, the abdominal walls appear to have lost their tone, so that there is an unusual degree of prominence, particularly of the lower abdomen. Flatfoot frequently co-exists. The complete muscular system lacks development and vigour, so that the patients are generally clumsy and slow in their movements. A certain degree of viscerop-tosis invariably accompanies the spinal error, but whether the visceral condition is primary or secondary in its relationship has not been decided.

DIAGNOSIS

As a rule the condition is self-evident. The examiner, however, must beware of confusing the static error with those more serious conditions which depend upon destructive changes in the vertebræ, of which tuberculosis is the most important

divisions of the disease, it is important to recognize that many cases of false scoliosis ultimately develop into examples of true scoliosis

It is now necessary to further subdivide true scoliosis into various groups according to the different causes which produce the deformity. The following groups are recognized —

- (a) *Congenital body errors*, such as malformation of the vertebrae, of the ribs, of the scapula, or of the lateral thoracic wall
- (b) *Pathological conditions of the vertebrae*, such as rickets, tuberculosis, tumours, fractures, or dislocations of the vertebrae
- (c) *Paralytic conditions of the spinal muscles*, such as infantile paralysis, spastic paralysis
- (d) *Extra spinal asymmetries*, such as wryneck, imperfect vision, pelvic obliquity from short leg
- (e) *Disease of the extra spinal soft parts*, as in empyema, scars or burns of the chest wall, cervical infection, abdominal or pulmonary disease
- (f) *Structural scoliosis* which has developed from persistence of the postural type

A conventional classification may therefore be tabulated as follows —

SCOLIOSIS	{ Postural Type	
	{ Structural Type	
	{	Congenital
		Vertebral disease
		Paralytic
		Asymmetrical
		Extra spinal disease
		Posture structural

TERMINOLOGY. A number of descriptive terms are used in connection with scoliosis. The lateral curve of the spine is spoken of as *right* or *left* according to the position of the convexity, its anatomical position is defined by the region in which it occurs—cervical, dorsal, or lumbar, if two curves exist, the upper one is spoken of first, such as right-dorsal, left-lumbar. It is sometimes the case that one curve is predominant, and that others, compensatory in character, are in existence above and below, and in this event it may be convenient to speak of the curves as primary and secondary. The terms C- and S shaped curves are respectively pictorially descriptive of (1) the postural curve, in which the complete spinal outline has a uniform lateral bend, and (2) the type in which a primary curve is accompanied by secondary compensatory deviations.

THE ETIOLOGY OF SCOLIOSIS

The subject of the etiology of scoliosis is such a diffuse one that it is difficult to discuss it without a great deal of elaboration. It is helpful

methods suggested for the resistant type ; if it is apparent, however, that these are producing no improvement, artificial support should be afforded. This is best done by the use of an apparatus composed of a pelvic band and light posterior uprights, a light linen or semi-elastic belt being incorporated, which will ensure support of the relaxed abdominal musculature.

Operative Treatment. From time to time operative treatment of various kinds has been suggested in extreme and resistant types of the disorder, but they have met with no success, and they are not to be recommended.

SCOLIOSIS

The human vertebral column is a rod-like structure composed of individual blocks of bone (vertebræ) superimposed one upon the other. The arrangement of the column is such that certain physiological antero-posterior curves exist in order to accommodate the individual to the erect position, but when viewed from the back the normal outline is a straight one, and any deviation of a series of vertebræ from the mid-line of the body justifies the description of a *scoliosis* or a *lateral curvature of the spine*. The deviation must affect a series of the vertebræ, for the displacement of a single bone does not constitute a scoliosis. In fact, the deformity may be defined as a lateral deviation of a segment of the spinal column from the mid-axis of the body, the deviation being accompanied by a rotation of the vertebræ which are involved.

VARIETIES AND TERMINOLOGY

There are different varieties of scoliosis, particularly from the point of view of etiology, and therefore it is necessary to adopt a classification of the disease which will express in some measure the clinical aspects of the different types. To begin with, it is important to recognize two groups of scoliosis :—

- (1) *Postural scoliosis* (total or false scoliosis); and
- (2) *Structural scoliosis* (organic or true scoliosis).

The first is largely a question of faulty attitude, it is a uniform error affecting the general outline of the spine, it is unlikely to be accompanied by much structural change in the individual vertebra, and the process of rotation is a negative consideration.

Structural scoliosis, on the other hand, is related, as its name implies, to pathological changes in the vertebræ or the associated tissues ; it has a variety of possible causes, its distribution is often localized to individual parts of the spine, while the changes of vertebral rotation play an important part in the establishment and in the persistence of the deformity. Though a dividing line exists between these two sub-

The deficiency of postural activity is followed by a lateral deviation of the spinal column, and, with its institution, secondary muscular



FIG 393 —Congenital Scoliosis (Girl 1 year and 8 months old)

The 7th and 8th vertebrae are represented by half bodies only, and there is a similar condition of the 1st and 3rd lumbar vertebrae. Synostosis of the ribs has occurred where the vertebral bodies are deficient.

changes occur which have a powerful influence upon the maintenance of, and the later developments of, the deformity. It follows that the muscles on the concave side are shortened while those on the convex

first to consider *the mechanism by which the spinal column is maintained in the erect position*. The principle of a vertical segmented column, capable of a great degree of flexibility, would suggest a somewhat unstable mechanical arrangement, but adaptations are in existence which make the spinal column a wonderfully perfect piece of mechanism. Stability is secured by a number of arrangements—by the method of articulation which is in existence between individual vertebræ, by the ‘stay’ influence of the longitudinal spinal muscles, by the supporting influence of the ribs extending between the spine and the sternum, by the equal distribution of weight through the shoulder and pelvic girdle, and by the multiplicity of short muscles and ligaments which fasten the individual bones together and to their respective ribs. Of these various influences, the effect of the lateral spinal muscles is perhaps of most importance.

The Etiology of the Postural Type. It is difficult to convey any exact idea of the origin of the postural type of scoliosis. In the various structural varieties, where there are obvious errors in the configuration of the vertebræ, or where gross changes are recognizable in the associated tissues, the problem is easy, but in regard to the postural type wide differences of opinion exist.

It would seem that there is a definite sequence of events—a neuromuscular error is probably responsible for the original lateral curve, and if this error can be explained, the difficulty is partly overcome. We have alluded to the influence of the long spinal muscles in maintaining the spinal column in its erect position; the spinal muscles, in common with other skeletal muscles, are capable of two kinds of muscular activity, the activity of movement, phasic and intentional, and the activity of posture, that prolonged and partly involuntary exercise of function which we sometimes speak of as ‘tone.’ The existence of these two types of activity is evidenced from a morphological standpoint, for ‘in certain invertebrates there are separate muscles differing in structure and in appearance for the execution of movement, and the maintenance of posture respectively’ (Bankart). In man the same muscle combines both purposes, and evidence of the collateral functions has been repeatedly demonstrated.

It has been suggested by Bottazzi and others that the sarcostyles constitute the movement mechanism, while the sarcoplasm controls the tonic or postural functions. Similarly, evidence of a double nerve supply has been provided by the experiments of Perronico, Boeke and De Boer. Most likely it is the ‘tonic’ or postural function of the long spinal muscles in health which maintains the spinal column in its correct attitude of extension and erect posture, and it is a natural corollary to assume that an error in this mechanism may result in a unilateral weakness and a subsequent deformity. Bankhart believes that postural scoliosis begins as a functional nervous disorder, and he draws an interesting comparison between this condition and that of ‘*myasthenia gravis*.’

MacLennan, of Glasgow, for example, ascribes the deformity to a primary error in the growth of the bones of the spinal column. He divides the spine as a support into two parts—an anterior column composed of the vertebral bodies and disks, and a posterior, formed of the laminae and the spinous processes. He believes that when scoliosis appears there is, or has been, an inequality of growth between the two columns, a more rapid growth in the anterior column resulting in a lateral displacement of the spinal outline. MacLennan has attempted to substantiate his views by a number of ingenious arguments, and we shall have occasion later to refer to an operative treatment which is based upon an acceptance of the theory of a primary disparity in growth.

Etiology of the Structural Type In the various structural types a primary error exists either in the outline of the spinal column or in the parts which are associated with it. The fault may be in the bones, and we have such varieties as the *congenital types* where one or more vertebrae are imperfectly formed, and the *destructive types*, where tuberculosis, syphilis, or tumour formation have partially destroyed the outline of the vertebral bodies, in fractures and osteo arthritis a similar influence is at work.



FIG 395.—An example of a Static Scoliosis affecting the upper Dorsal Region

A structural scoliosis may follow a gross muscular error, and therefore we find the deformity developing in association with infantile paralysis affecting the spinal muscles, with syringo-myelia, Friedrich's ataxia and hemiplegia. Disease of the soft parts which lie in relation to the spine may inaugurate a structural scoliosis, and therefore the deformity may follow such conditions as empyema, burns of the chest wall, and acute infections.

The group of cases of scoliosis which are traceable to errors of symmetry such as pelvic obliquity from a short limb are usually grouped under the heading of structural varieties, and these influences are therefore etiological factors. In certain instances, however, errors of symmetry are the predisposing factors in the acquisition of a postural deformity.

side are lengthened ; the shortened muscles lose the power of elongation, and the restoration of their functions is correspondingly interfered with ; on the other hand the muscles on the convexity undergo a process of stretching which is peculiarly inimical to their physiological activity, and therefore to their recovery of ' postural ' function. With the institution of the lateral curve gravity comes into play, and its influence is probably a very considerable one. As the lateral curve further develops, soft tissue structures are adapted and shortened, and the bones are remodelled. These, however, are secondary changes, which are discussed under the heading of pathology.

Keith, in his lectures on *The Evolution of Posture*, makes some interesting remarks on what may be termed the morphology of scoliosis. He believes that the muscular deficiency is first evidenced in those muscles which act on the short levers of the spine, the muscles which

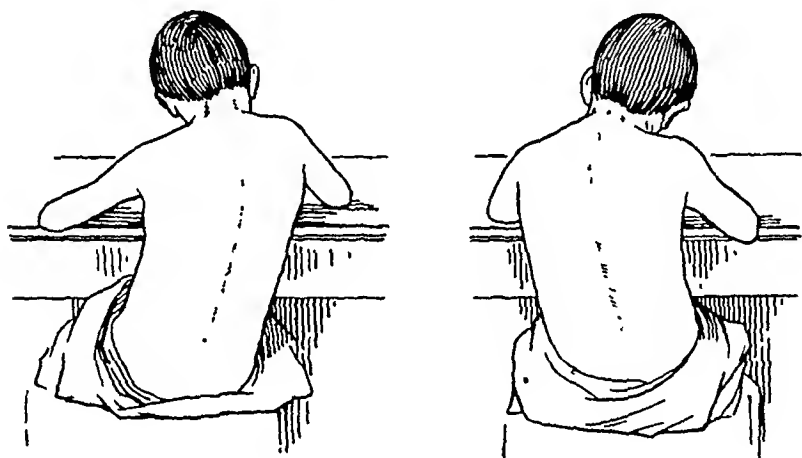


FIG. 394.—The Effect of a lazy Attitude in the acquisition of a postural Scoliosis.

act on the long costal levers being more resistant. In attempting to rest the exhausted short spinal muscles, the vertebræ undergo a process of rotation, so that the articular processes begin to lock and the transverse processes to rest upon the necks of the long costal bones (ribs). Keith believes that this process is the beginning of lateral curvature and especially of that rotatory change which is so distinctive.

Secondary Influences. The belief in a primary neuro-muscular error is strengthened by general considerations, psychological and otherwise. There is a frequent association of scoliosis with neurasthenia and with a neuropathic family history (Oppenheim). Its first appearance is generally coincident with the school age of life, and especially with the period when the strain of mental work is first beginning to be appreciated ; in many cases there is a history of overwork, such as studying for an examination.

It is, however, necessary to say that such a neuro-muscular explanation as we have outlined has not met with universal acceptance.

but they are never so intense as the primary one. The individual pathological changes may be conveniently summarized under the following headings —

Changes in the bodies of the vertebræ The vertebral bodies tend to undergo a wedge shaped deformity on the concave side of the curve the outline is compressed, on the convex side there is a relative, and in severe cases an absolute, expansion. The vertebræ at the apex of the curve are the most seriously affected, and on the concavity of the curve the degree of compression may be so marked that synostosis of adjacent vertebræ occurs over the intermediate one.

In certain instances the body becomes lozenge shaped rather than wedge shaped, this change is met with at the junction of primary and secondary curves, and is the result of the sliding action of superimposed vertebræ upon one another.

The disks may be affected in severe cases, they tend to become squeezed out on the concave side of the curve.

Changes in the Pedicles and Transverse Processes The level of the pedicles is altered—those on the concavity acquire a lower level than the corresponding processes on the convexity, they are also altered antero posteriorly, the convex pedicles acquiring an antero posterior direction, while the concave pedicles are set in a transverse axis.

The transverse processes undergo a similar displacement to the pedicles, the process on the convex side becoming more antero posterior, while that on the opposite side is set transversely—a result of the changes in the relative positions of the transverse processes is a narrowing on the side of the convexity of the space between the transverse process and the spinous process.

Changes in the Spinous Processes The spinous processes are deflected towards the convexity of the lateral curve except in certain severe cases in the lumbar region, where the spinous processes are diverted towards the concavity.

The spines deviate less than the bodies, so that the curved line



FIG 397.—Scoliosis. Lateral view illustrating the Rib Hump on the Side of the Convexity.

There is lastly the group of cases which, beginning as types of the postural variety, have rapidly or gradually acquired the characteristics of the structural class; it is therefore correct to say that a postural scoliosis may be a stage in the development of the structural type.

The influence of rickets in the causation of the disease is important, but the method by which its influence is effected is obscure. The muscular weakness with which the disease is associated is liable to result in an abnormal degree of antero-posterior curvature of the spinal

column, and if no attention is paid to the error, the lateral curve is apt to ensue. Many instances of rickety scoliosis are exaggerated by the habit of carrying the child upon the mother's or the nurse's arm so that a lateral curve is induced.

PATHOLOGY

The pathology varies according to the degree of the deformity. In an *early postural case* the lateral curve of the column and an adaptive shortening of certain of the soft parts embrace the main pathological changes. As the deformity becomes more marked, changes are induced very similar to those met with in the structural types. The changes as we shall describe them are those met with in a *structural case of average severity*.

The most striking feature is the lateral rotatory deformity when the spinal column is viewed in an antero-posterior axis. The spine is bent or curved laterally, while it is of the vertebræ always turning towards the convexity of the curve. The deformity is usually limited to the pre-sacral vertebræ, though in the most severe types the sacrum and coccyx may be involved. The outline of the lateral curve may be gradual, angular, or even acute.

The principal changes in the spinal column are distributed over a definite area, which is conveniently termed the *primary curve*; above and below this point *secondary or compensating curves* may develop,



FIG. 396.—Scoliosis. Posterior view of Skeleton showing the Deviation of the Spine and the characteristic changes in the Ribs.

are stretched over the bones, and though they may not show the same degree of wasting as the muscles on the concavity they are often the subjects of a fibrous degeneration

In a description of the muscular changes, attention is usually directed to an alteration in the position of the diaphragm—it becomes oblique so that it is lowered on the convex side of the dorsal curve

Changes in the Thorax The degree of deformity which the thorax suffers secondary to the scoliosis varies with the position of the primary error, in lumbar scoliosis the thoracic changes are slight, in mid dorsal scoliosis, on the other hand, they are early noticeable, and they rapidly become pronounced. The more important alterations may be summarized as follows—

(1) The general outline of the thorax is displaced so that it passes in an opposite direction to the convexity of the curve of the spine

(2) The transverse section of the thorax is altered so that the internal surfaces of the shafts of the ribs on the convexity of the curve are brought nearer to the front of the vertebral bodies, and the half of the thorax on the side of the convexity is thus seriously diminished in capacity

(3) As the bodies of the vertebrae undergo a rotation towards the convexity of the curve, there is necessarily a change in position of the transverse processes, and the ribs, being attached to the latter, suffer a displacement which is highly characteristic of scoliosis. The

ribs on the convex side of the lateral curve show a backward increase of their angularity, forming a more or less prominent ridge on the side of the back of the thorax. This prominence is known technically as the 'rib hump' or 'the rotation'. On the concave side the rib angle is opened out and an increased curvature thus becomes apparent anteriorly.

(4) The sternum resists displacement until a late stage



FIG 399—Static Scoliosis of the upper Dorsal Region (Girl 10 years old)

Compensatory curves exist in the dorso-lumbar and cervical regions and the deformity of the out growing hip is well shown

formed by delineating the tips of the spinous processes is the same in character as the curves of the bodies, only less in degree.

In a characteristic case the spinous process is curved so that its root deviates concavewards and the tip convexwards; in addition it may be twisted on its long axis.

Changes in the Articular Processes. It is said that in examples of early scoliosis the joints between the articular processes on the cavity of the curve are enlarged, and the cartilages at first thickened. In more advanced cases synostosis between the joints of the articular processes on the concavity is met with; the early cartilaginous changes probably predispose to the ossification.



FIG 398.—Static Scoliosis of Mid-dorsal Spine, with well-marked Rib Hump.

Changes in the Laminæ. The laminæ on the convex side are shortened and atrophied; in advanced cases of the disease synostosis between the laminæ on the concavity is frequent, and this factor when existent has a considerable influence upon the possibilities of correction of the deformity.

Changes in the Costo-vertebral Joints. These are depressed on the convexity and somewhat shortened on the concavity of the curve. Secondary to the rotation of the bodies, the position of the joints on the convexity appears to be displaced backwards, while those on the concavity occupy a forward position in contrast to the normal.

Changes in the Soft Parts.

(1) *The Ligaments.* The changes which these undergo are very much what might be expected. The interstitial and the costo-vertebral ligaments are elongated and atrophied on the convex side, while they are tense and short on the concave side. A peculiar change is noted in the anterior common ligament. It tends to become bunched together into a cord-like structure, with a prominent edge towards the concavity and an ill-defined border on the convexity. It is interesting that the posterior common ligament does not suffer a similar displacement.

(2) *Muscles.* Unless there has been a primary muscular lesion secondary muscular changes are only met with in the most severe types of the deformity. In extreme degrees of scoliosis all the muscles of the back share in a general atrophy, those on the concavity of the curve being the more severely affected; on the convexity the muscles

of the scapulæ is outlined, their relationship to the spine is noted, and any rotation which they may have undergone is recorded

The Demonstration of the Lateral Curve The next step in the examination consists in delineating the spinous processes so that the demonstration of the lateral curve is facilitated. Two procedures are accordingly adopted. (1) the tips of the spinous process are marked out by touching each with a skin pencil or ink brush, and the resulting line of marks is accepted as representing the spinal curve, though, owing to the presence of rotation, it does not indicate the position of bodies of the vertebræ

(2) The median plane of the body is determined by holding a plumb line behind the patient so that the line extends from the middle of the occiput to the cleft between the buttocks. By contrasting the dotted outline of the spine with the median plumb line, it is possible to demonstrate the presence of a lateral curve, and also to estimate with accuracy the situation in which it exists

The Estimation of Vertebral Rotation It is important for the surgeon to have some knowledge of the degree of vertebral rotation which has accompanied the lateral curve, and this estimation is made by observing the displacement of the ribs. The child bends forwards until the trunk is horizontal, the knees being straight and the arms hanging down. The surgeon now glances along the spine from the back with his head on a level with the spine, and any lateral upward prominence is accepted as an evidence of rotation, and its exact situation is noted. If the prominence is slight, if it is uniformly distributed along the length of the spine, and if it occurs on the concave side these characteristics indicate a postural curve, if, on the other hand, the prominence is a localized and a marked one, and if it occurs on the convex side of the curve, the scoliosis is recognized as being structural in character. The presence of rotation is further made manifest by comparing the transverse axis of the shoulder girdle with that of the pelvis. The surgeon stands behind the patient, and, looking down from above, he estimates whether both are in the same lateral plane or whether the shoulder girdle crosses the outline of the pelvis at an angle, this sign is chiefly evident in examples of the postural type

The Examination of the Flexibility of the Spine For various reasons it is important to have some idea of the flexibility of the spine—for reasons of treatment, of prognosis, and of diagnosis. In order to bring out the maximum amount of flexibility all superneumbent weight must be removed from the spine. This is achieved to some extent by laying the child face downwards on a flat surface, but more complete relaxation is gained by the method recommended by Whitman. The child stands facing and close to the edge of a table, which should be of such a height that its surface corresponds to a point just below the hip joints. The child bends forward so that its trunk lies

Changes in the Pelvis. When the scoliotic curve affects the lumbar spine, obliquity of the pelvis is apt to occur, and the sacrum may undergo changes of lateral curvature or of rotation: the latter is important, because it is directly responsible for the pelvic obliquity which may develop.

Visceral Changes. It is apparent that a considerable degree of compression of the lung on the side of the convexity must occur, more especially when the scoliosis affects the dorsal spine; this encroachment is reflected upon the heart and the aorta. Both are displaced to the side of the concavity, and the aorta may be curved and kinked. The general result is cardiac hypertrophy with dilatation, followed in severe cases by venous stasis. The trachea and cesophagus are dis-

placed so as to follow the outline of the spinal curve, the position of many of the abdominal viscera is also changed, the displacements and the viscera affected varying with the position of the curve. Various degenerations may ensue upon the displacements.



FIG 400.—An example of an upper Dorsal Static Scoliosis illustrating a considerable degree of "Rib-hump."

EXAMINATION

The child should be examined according to a regular routine. The body is uncovered to immediately below the waist so that the iliac crests are apparent and the upper part of the natal cleft is in view. The child stands with the back to the sur-

geon, resting squarely on both feet with the arms hanging by the sides. A few minutes should elapse before observations are made so that the spine may assume a relaxed position.

General Inspection. The examination begins with inspection, the following points being investigated:—

(1) *The Symmetry of the Body Outline.* This point is demonstrated by observing and contrasting the brachio-thoracic triangles on each side; in comparatively early degrees of scoliosis a body displacement occurs which leads to asymmetry.

(2) *The Level of the Shoulders.* Elevation of one shoulder is often the earliest sign to be apparent in scoliosis, and it is one which frequently attracts the untrained eye.

(3) *The General Outline of the Back.* Any increase or diminution of the antero-posterior physiological curves is observed, the position

tration of this there are the frequently quoted experiences that the deformity is first discovered when the child is being fitted by a dress maker, or when the patient is first brought for surgical advice because of some associated and more apparent distortion, such as a prominent hip or a high shoulder

DIAGNOSIS

Demonstration that the outline of the spine is so distorted as to give the appearance of a lateral curvature is usually sufficient to distinguish the case as one of scoliosis, and when it is found that the condition is rarely associated with pain and that it has developed in the years before puberty, there is little doubt as regards the diagnosis. But more than a simple recognition of the error is necessary, it is important that it be classified as postural or structural, and some opinion must be come to regarding the etiology. It is convenient at this stage to recall the relative characteristics of the postural and the structural types

The postural type is usually a gradual curve towards one or other side, and in the early stages compensatory curves are absent. This curve disappears on suspension or recumbency, it is rarely rigid, and the 'rib hump' is slight. In contrast to this in the *structural type*, rotation of the vertebrae is marked, and therefore the prominence of the rib hump is correspondingly great, the curve may be a single one, as when it occurs in the lumbar region, but in general, compensatory curves are present, and the spine early acquires a diminution in the degree of flexibility

Differential Diagnosis As far as the exclusion of other diseases is concerned, tuberculosis of the spine is the only one which may give rise to difficulty. A lateral curvature of the spine may occur in the early stages of Pott's disease at a date prior to the appearance of the gibbous deformity, but the associated local and referred pain, the fixation of the spine, the stiffness of gait, and the impairment of the general health are sufficient to distinguish the condition as tuberculous

A second difficulty, but a less real one, may arise in connection with the later stage of Pott's disease. An unequal destruction of the vertebral body may result in a kypho-scoliotic deformity so that a lateral bend accompanies the kyphosis. Any doubt will be dispelled by the history of the case, by the fixation of the spine, and by the appearance on X-ray examination

PROGNOSIS

The prognosis really centres round the question which parents so often put, 'What are the prospects of curing, of improving, or of arresting the deformity?' "

In answering such questions it is necessary to ask oneself a further one "Is the scoliotic curve a postural or a structural one?" for in

along the table face downwards, and, while it is in this position the relaxation is completed by placing a stool behind the knees so as to bend them.

The information which this examination affords is of use in several ways: in the diagnosis it aids in distinguishing between postural and structural curves, for the postural curve becomes straight in recumbency, while structural curves are improved but not corrected. It is useful as a guide to treatment, because it illustrates the persistence and the extent of the deformity, and thereby indicates the appropriate treatment. The information is essential where prognosis is concerned, because the restoration of symmetry by inducing flexibility indicates an early case, and one amenable to treatment.

X-ray Examination. Every case should have the benefit of this method of investigation. In certain extensive forms of kyphoscoliosis it requires the evidence of an X-ray plate to make the diagnosis clear, while the examination affords exact evidence of the degree and character of the curve, of the amount of distortion of the individual vertebræ, and the existence of congenital defects in the spinal architecture. Both antero-posterior and lateral X-rays should be taken, and it is helpful to indicate the tips of the spinous processes by small adhesive lead points, for by this manœuvre the degree of rotation can be accurately estimated.

The Record of the Deformity. It is useful to have some method of keeping a permanent record of the spinal error. Reference to it will indicate retrogression or improvement in the progress of the case. No really efficient method of record has been evolved, but various methods are in use. Photography is helpful, lead tape outlines may be taken from the back and transferred to a permanent record on paper, or a small-mesh net may be placed on the back and the outline of the scoliotic error transferred to it by dots of coloured ink.

CLINICAL FEATURES

As the condition is essentially one of deformity, it is unusual for subjective symptoms to be present to any great degree unless the deformity is extensive and there are associated visceral displacements. Pain may be complained of as a backache, and it is suggestive that this subjective symptom is usually exaggerated after attention has been drawn to the error. In some deformities pressure of the lower ribs on the crest of the ilium causes local pain. Displacements of the lungs may lead to shortness of breath, and it is recognized that the diminished respiratory capacity may predispose the individual to pulmonary tuberculosis. Displacements of the stomach and liver may lead to various digestive disturbances. Many children show associated loss of vigour with impairment in the general health. In the majority of cases, however, symptoms are absent, and, in illus-

- (d) Are the school conditions satisfactory in so far as seating and working accommodation are concerned ?
- (e) Is the condition of the eyes and ears healthy ?
- (f) Does any bodily asymmetry, such as a short limb, exist ?

All these various aspects of the child's daily life are carefully investigated, and the correction of any apparent error is arranged for. The elaboration of the second and third details is secured by arranging that the child is placed under the care of an expert who shall be responsible for the massage and for the teaching of those exercises which are designed to secure equal flexibility of the spine and improved development of the spinal muscles. It is impossible to enter into full detail regarding the various spinal exercises, for their description is a matter of considerable length, but this point is important, that, however good the teacher and masseuse may be, the surgeon should continue to supervise the conduct and progress of the treatment.

Structural Scoliosis

When the treatment of a structural scoliosis is undertaken the surgeon is faced with a problem which may be extremely difficult. The error is one affecting the bones, and with such an unyielding structure, correction is never easy, and as a further complication there is the attitude of patient and parents, for if treatment is to be successful it demands prolonged care and thorough prosecution, and it is on this point that considerable difficulty may be encountered.

SCHEME OF TREATMENT

A graduated scheme of treatment has been evolved in order to meet the necessities of cases of varying severity, and, beginning with the mildest type of structural scoliosis, its arrangement is as follows —

- 1 Gymnastics
- 2 Gymnastics and supports
- 3 Gymnastics combined with stretching and supports
- 4 Forebile correction
- 5 Operative treatment

1 **Gymnastics** As has been indicated in connection with postural scoliosis, the object of gymnastics is twofold —

- (a) To loosen the spine and so increase its flexibility
- (b) To develop the muscles so that their functional powers are increased

The details of the exercises are similar to those employed in connection with postural scoliosis, they should be carried out for periods of one to two hours a day, and it is essential that they be performed under the supervision of an expert teacher, only when it is apparent that correction has been secured should the child be permitted to carry

these two types very different views regarding the prognosis will hold good.

The Postural Curve. The average postural curve is not a serious deformity. Even in the absence of efficient treatment it may persist throughout life without showing any marked increase in extent and without greatly affecting the general health. It will not, however, disappear spontaneously, and there is always the possibility that it may develop into a curve of the structural type with its associated risks and disabilities. Under efficient treatment the postural curve offers every prospect of complete cure.

The Structural Curve. Where structural curves are concerned the position is more serious. In the absence of treatment there is the certainty that the deformity will increase, and it may do so rapidly. If the deformity is recognized early, if thorough and painstaking treatment is thereafter followed, and if the patient is of an age when growth is still active, there is a fair prospect of complete recovery. Modification of these conditions will mean that the deformity can be improved but not cured.

The prognosis is further influenced by *the class of structural scoliosis to which the case belongs*. A rachitic scoliosis is the most difficult in which to obtain a good result, the congenital type is more tractable, but still difficult, the best results will probably only be obtained in structural scoliosis of the paralytic variety.

TREATMENT

It has been apparent throughout the foregoing account how important is the distinction between the postural and the structural varieties, and such a distinction is especially necessary in regard to treatment.

Treatment of the Postural Type

Recognizing that a postural scoliosis is but the persistence of an error of posture, certain ideals guide one in treatment. These are:—

- (1) The elimination of errors of environment or of compensation which may originate and maintain the deformity.
- (2) The restoration of flexibility of the spine in all directions—the loosening of the spine, so to speak.
- (3) The development of the muscles, so that they are better able to maintain the spine in a correct attitude.

The first ideal, the elimination of various adaptive errors, calls for investigation of the following points:—

- (a) Is the child growing at such a rate as to overtax the muscular system?
- (b) Are the hours of work too long?
- (c) Are the conditions of clothing satisfactory?

ciently to raise the heels off the floor, the child resting in a tiptoe position

- C The traction force may be made to equal the body weight, the child being suspended until the feet swing free
- D By fastening the child to a seat with straps round the thighs a traction force can be applied as severe as the surgeon may desire

This method of suspensory or passive stretching has disadvantages. Its corrective value is not great, especially when rotation is present, and it is somewhat of an ordeal, especially to the nervous child



A



B

FIG 401 —The Scoliosis Correction Frame

A The frame repaired B The child in position on the frame with the correction bands adjusted preparatory to the application of the plaster jacket

Recumbency stretching is a less exhausting and a more effective method of correction. It is easy in its application, and it demands no special apparatus. The child lies face downwards on a long narrow table, the body resting on the table, while the thighs are bent over the edge and the knees are flexed. Three broad canvas bands are passed round the child's body in such a way that both fixation of the spine and correction of the deformity are carried out. The upper and lower bands ensure the fixation, they pass at the extremities of the spine on the side corresponding to the concavity of the curve, and are secured to cleats on the side of the table. The middle band produces the correction, it passes around the thorax so that the middle of the band is over the summit of the convexity of the curve, the upper end is fastened to a cleat at the table edge, and the lower or under end is fastened by means of a rope into a compound pulley attached to the table edge. When traction is made upon the rope a double corrective influence is exerted—the curve is actually diminished, while the rotation is reduced

them out at home. As the exercises demand considerable energy, and there is therefore a corresponding strain upon the patient's vitality, certain precautions are necessary. The child should be medically examined before the treatment is begun, and a careful record of weight should be kept between treatments, in case the strain is proving too severe.

Treatment by gymnastics alone is suitable only for the mildest type of structural scoliosis, and in this connection it is convenient to refer to its associated dangers. The benefit of gymnastics mainly proceeds from the loosening of the spine which the exercises induce, but, if this benefit is to be retained, muscular development must proceed coincidentally, for, if the latter benefit is delayed the loosening will be followed by a 'sagging' of the spine and an exaggeration of the scoliotic deformity. This is the explanation of the danger which exists if moderate degrees of the disease are treated by exercises alone, because the muscular development is so imperfect that without artificial support the loosening effect of the exercises will result in exaggeration of the error.

How is one to estimate whether or not exercises alone are sufficient? The answer is by observation of the patient in the intervals between treatment; if the improvement is maintained until the next séance benefit is being derived, and the case is suitable for treatment by gymnastics alone.

2. Gymnastics and Supports. When the development of the scoliosis is such as to justify the qualification of 'moderate' in degree, treatment by exercises is advised, but it is necessary that the child should wear supports during the intervals for the reasons already explained. The supports are intended solely to maintain the degree of correction which the exercises have procured. There are three varieties of these in common use—removable plaster jackets, corsets, or metal braces.

The ease with which the plaster jacket can be applied, and the accuracy with which it can be fitted are advantages which lead to its being the most frequent method of choice.

3. Gymnastics, Stretching and Supports. If it is apparent that the child is not improving under the régime of exercises and support, it is necessary to invoke the aid which is derived from the stretching of the spine. This is carried out either in suspension or in the recumbent position.

Suspensory stretching is performed by fitting the child with a head sling which embraces the chin and the occiput, and is attached to the roof through the medium of a compound pulley. The surgeon controls the degree of suspension, and the force exercised may be said to be of four different degrees according to the amount of the deformity.

A. In a mild case the soles of the feet remain in contact with the floor.

B. Where this is not sufficient the traction may be increased suffi-

bands and one correcting band are now applied in the manner described in connection with the stretching technique. The upper and lower fixation bands are secured to the side bars of the frame, and pass at the upper and lower extremities of the spine on the side corresponding to the concavity of the curve. The correcting band passes around the convexity of the curve, and is capable of adjustment most conveniently through the medium of a ratchet, by tightening this band, more especially on its under loop, correction of the curve and of the rotation is obtained. The bands are carefully padded at their points of contact with the skin with thick layers of felt. When the maximum of correction has been obtained a plaster jacket is applied which incorporates the various retention and correction bands, and when the plaster is sufficiently hard the side straps are severed where they merge from the jacket and the patient is lifted into a standing position. The longitudinal supporting bands are removed, a finishing plaster bandage is applied, and is extended upwards so as to include the shoulders, and in high cases of the deformity, the lower neck.

PRELIMINARIES AND AFTER TREATMENT The child should be in fair general health when the application is made. Exercises and even a course of preliminary stretching are of advantage, because they increase the flexibility of the spine.

An anæsthetic is contra indicated, because the patient's sensations are considered in estimating the amount of corrective force with which the jacket is applied; moreover, no actual pain should be induced. An efficient corrective will cause mild discomfort, and it should always be borne in mind that any discomfort previously induced will be exaggerated when the erect position is resumed. A degree of correction which gives rise to difficulty in breathing is probably too severe.

A certain proportion of cases suffer from such unpleasant sequelæ, as shock, collapse, or cyanosis, and it is therefore essential that children should be kept under observation for at least twenty four hours after the application.

Abbot's Corrective Jacket Abbot's method of applying a corrective jacket deserves special consideration. The originator claimed great advantages for it, he believed that it provided a method of 'simple, rapid, and complete reduction of the deformity in fixed lateral curvature of the spine,' but later results and to some extent the experience of other surgeons have failed to justify the optimism with which the method was at first regarded.

The procedure is somewhat similar to that employed in applying a corrective jacket in rickets; a specially designed frame is used and the patient lies supine in a hammock attached to the frame, the legs being flexed and suspended to an over bar. The essentials of the corrective position are that the patient is placed on his back on a sagging hammock, and the legs are elevated in order to increase the flexion assured by the weight of the body. The shoulder on the side of the concavity of the curve is raised and drawn forward by the

from the fact that the upper end of the band is fastened while the lower end exerts an under and circular traction upon the ribs.

4. Forcible Correction. This method is suitable for cases which have failed to respond to the afore-mentioned methods of treatment, and to cases in which the deformity may be classed as severe. The principle of the treatment is that the curve is corrected by traction on its two extremities while pressure is made on its convexity, and when the best position has been obtained by these means a retentive plaster jacket is applied.

A course of exercises and massage should invariably precede the application of the jacket, for only by such treatment is it possible to secure such a mobilization of the spine as will respond to the later corrective appliance.

THE ROUTINE OF STAGES OF FORCIBLE CORRECTION

There are two distinct stages in the method of forcible correction—(1) the stage of application of the corrective jacket, and (2) a subsequent stage where the improvement obtained by the original jacket has to be maintained, and if possible increased. It is necessary to briefly describe the more important details of these different stages.

(1) **The Stage of Application of the Corrective Jacket.** The process followed is very similar to that adopted in connection with the 'stretching' method of treating scoliosis, with this distinction, that the improvement which 'stretching' induces is maintained by the application of a plaster jacket. The jacket may be applied in suspension or in recumbency.

Application in Suspension. The child is suspended through the medium of a rope and pulley, and head bands to such an extent as to secure the maximum degree of correction. While the correction is being maintained a plaster jacket is applied, the various bony points are padded, and the jacket is fitted in the way already described in connection with tuberculous disease of the spine. The jacket must be a close-fitting one, accurately moulded to the pelvis, from which it takes its fixed point: its upper level will depend upon the position of the scoliosis, but even in the lowest and the mildest variety it should extend to above the shoulders and around the lower neck. Accurate moulding is essential if the jacket is to be beneficial, but at its best the method leaves a good deal to be desired; it corrects lateral curvature, but it has comparatively little effect upon rotation, and therefore it is only suitable for early, mild, and flexible examples of the deformity.

Application in Recumbency. This is the method which is found most efficacious, and therefore it is the one in general use.

The child lies on its back with hips and knees flexed in the middle of a gaspipe parallelogram frame, supported at the level of the axillæ and the hips by close bands of webbing and by two longitudinal bands. A seamless vest of stockingette is worn, and such prominent bony parts as the iliac crests and the sacrum are padded with felt. Two fixation

(2) If sufficient correction has been obtained by the original correction jacket, and further manipulation is considered unnecessary, the improvement is retained and even carried further by the use of a 'removable' corrective jacket. Briefly its application is as follows: an accurate model of the torso is made of the child's thorax, and this is altered by cutting down the prominent side and building up the collapsed side—in other words, the model is made more normal and symmetrical in shape. It is also usually advised that its vertical length should be increased by bisecting the model at the waist in a horizontal plane and inserting in the interval a flat board, roughly the transverse outline of the model, about half to three quarters of an inch in thickness. With the aid of strong glue the segments are fastened in position, and upon the corrected and elongated model the removable jacket is made of plaster of Paris. Being moulded to a corrected model of the patient's chest, and moreover being longer than the actual subject, it exerts a double corrective influence, both through rotation and extension.

The jacket having been modelled, it is split down the front, a window is cut in that portion which corresponds to the concavity, while that which will be in contact with the convexity is lined with thick felt so as to exert a further corrective influence on the posterior displacement of the ribs. The edges of the jacket are bound with leather, and straps and buckles are added. It is applied while the child is lying in a fully extended position with the arms above the head, and it is buckled in place before the patient stands erect. It should be worn night and day, being removed for an hour daily to permit of gymnastic exercises.

THE TREATMENT AFTER CORRECTION If correction has been successfully achieved, steps should be taken to prevent recurrence of the deformity. An inspection of the spine is made at regular intervals, exercises are continued, and if it is found that some type of mechanical appliance is necessary to hold the spine in a correct position, a light quadrilateral metal brace is worn.

Cases which are unsuitable for Treatment by ordinary corrective Jackets

High dorsal curves are unsuitable for treatment by ordinary corrective jackets, because, at such a level, it is difficult to exert pressure on the displacement. Two methods have been suggested to overcome the difficulty—the use of a Taylor's head ring attached to the jacket so as to secure and to extend the head, or the high Minerva jacket applied in full extension, as suggested by Calve.

Operative Treatment

Various attempts have been made to improve the unsightly deformity of severe scoliosis by operative treatment. It would seem an obvious indication to resect the posterior projection of the displaced

arm, the other shoulder falling backwards and downwards. Side pressure and rotation force are exerted by means of webbing straps connected with the top and sides of the frame, tightening being secured by means of ratchets. Correction having been obtained, the thorax is encased in plaster while the correcting bands are still *in situ*, and when the casing is hard the connections with the edges of the frame are cut, and the child is lifted out. Large windows are now cut in the plaster, one behind and one in front. The former is as large as possible, and is situated where the ribs are depressed: the latter is made on the opposite side to allow the ribs which bulge posteriorly to push forward. Through the posterior window between the plaster and the chest wall strips of felt are inserted, their size and thickness being gradually increased as correction proceeds.

The general consensus of opinion is that, so far as efficacy is concerned, Abbot's jacket has no advantage over the simpler methods, and is moreover unsightly and uncomfortable.

(2) **The Course of Treatment after the Corrective Jacket.** The corrective jacket having been successfully applied, one of two courses is open:—

- (1) The jacket may be kept *in situ* while steps are taken to further increase the degree of correction; or
- (2) After one or more corrective jackets have been in place for some time, a removable corrective jacket may be substituted.

(1) In the event of the original corrective jacket being kept in place, two windows are cut in it in order to allow expansion of the deformed chest, and to permit of the introduction of felt, which by pressure actually corrects displacement. A large window is cut posteriorly from the half of the jacket which corresponds to the concavity of the curve, i.e. to the depressed side of the chest behind. Laterally such a window extends from the spine to the anterior axillary line, vertically it extends from the level of the scapular spine to immediately below the last rib. Anteriorly a slightly smaller window is removed from the side diagonally opposite, that is, over the area of depressed ribs in front. Such removals make it possible for the depressed parts of the chest to be expanded by respiration and counter-pressure while the prominent parts are compressed. Pads of felt are now inserted between the prominent parts of the chest and the fixed portions of the jacket, and this procedure is continued each week as correction gradually proceeds. There comes a time when the pads are so large that the jacket is pushed away from the patient so that it no longer fits; it is then necessary to remove the jacket and to apply a fresh one. Such a corrective jacket is employed as long as there is evidence that improvement is being obtained: when no further change is obtainable, the fixed jacket is dispensed with and a removable one is substituted, while gymnastics, exercise, and massage are resumed or begun.

scoliosis by removing sub periosteally the bodies of one or more of the vertebrae which form the summit of the curve. Through an incision along the line of the vertebral spines the transverse processes and the vertebral ends of the ribs are exposed, two or three of the costo-transverse segments are removed, and through the space thus obtained, access is gained to the side of the vertebral bodies. The rotation actually simplifies the possibilities of access. The pleura is carefully packed aside, the body of the vertebra pierced, and the cancellous tissue of the interior is removed with a sharp spoon, one or more bodies being operated on according to the extent of the deformity. The wound is closed without drainage, and by forcible manipulation an attempt is made to correct the lateral curve, correction being made possible by the collapse of the excavated vertebrae. With the spine in the improved position a plaster jacket is applied, and this is kept in place for several months.

MacLennan has been favourably impressed with the results of this manoeuvre, but the operation is one of considerable severity, and results are not yet available to enable one to speak of the permanence of the improvement.

ribs, and this operation has actually been practised by Volkmann and Schaffner, but the results have been so disappointing that the operation has been abandoned. Lengthening of the ribs on the concave side has been suggested and practised by Hoke, but this attempt has been a failure.

A second line of operative treatment has aimed at inducing ankylosis of the spine. Such operations as Hibbs's and Albee's have come to occupy a very real place in the treatment of Pott's disease,



FIG. 402.—An example of Severe Mid-dorsal Scoliosis treated by implantation of Bridge Grafts (Boy 8 years).

One year has elapsed since the operation.

and the principle has lately been applied with a certain promise of success in scoliosis, but the objection to it is that, while it results in fixation of the posterior part of the spine, comparatively little control is exerted upon the bodies, these continuing to rotate as the child grows.¹

MacLennan has lately attempted the operative correction of rigid

¹ We have lately had good results from the implantation of bridge grafts into the concavity of the curve.

fascia which later become the coverings of the cord, and a special layer of fascia derived from Scarpa's fascia. During the fifth and



FIG. 403A.—Dissection of Fœtus 5 months old

The true descent of the testis is just beginning the open end of the processus vaginalis is well seen

sixth months the onward progress of the gubernaculum and its accompanying structures proceeds. During the seventh month the testis and epididymis are passing down the canal by the eighth month they

CHAPTER XXXII

HERNIA AND UNDESCENDED TESTIS

HERNIA

INTRODUCTORY. The large percentage of hernia cases in children are examples of the inguinal type. Umbilical herniæ are moderately common, while femoral herniæ are, in our experience, exceedingly rare.

INGUINAL HERNIA IN THE MALE

THE ETIOLOGY OF INGUINAL HERNIA

Some years ago there was discussion as to whether the inguinal sac of the child was a congenital deformity or an acquired error, but at the present day an overwhelming consensus of opinion favours the view that the hernial sac of the child is a congenital defect, that it is, in fact, the imperfectly closed *processus vaginalis*. Some knowledge of this structure is therefore necessary to a proper appreciation of the subject.

The Formation of the Processus vaginalis. During the early months of intra-uterine development, the future testis and epididymis develop as intra-abdominal structures, the former originating from the genital ridge, the latter from the Wolffian body. They rest on the posterior abdominal wall behind the parietal peritoneum at the lower pole of the kidney, and during the third month of foetal life they come to lie side by side upon the posterior wall of the iliac fossa. Although both possess distinct mesenteries, they ultimately acquire a common attachment to the posterior abdominal wall, the common uro-genital ligament, the portion of the ligament above the testis being called the *plica vascularis*, while the extension below is known as the *plica gubernatrix* or *inguinal fold*. At this time (third month) there is no trace of an inguinal canal. At the fourth month the gubernaculum begins to extend downwards against the anterior abdominal wall towards the scrotum, at this period represented by a pouch of subcutaneous tissue; it forces its way through the abdominal wall, and by its passage forms the inguinal canal. As the gubernaculum descends, it carries with it a variety of structures, the most important of which are a process of peritoneum (the *processus vaginalis*), several layers of

the iliac fossa, invades the abdominal wall, every layer of which it carries as a prolongation into the scrotum. It is an invading army of cells. It draws with it into the scrotum the peritoneum of the iliac fossa, on which the testis is dragged like a log on a sledge.

During the ninth month, after the descent of the testis has been completed, the processus vaginalis becomes occluded in two situations—at the internal ring and immediately above the testis, the intervening portion should thereafter become obliterated. A patent processus which communicates with the abdominal cavity is the essential etiological factor in the development of a hernia, while a patency between the two points of obliteration is the origin of a hydrocele of the cord.

Secondary Etiological Factors—Factors which increase Intra-abdominal Pressure While the essential error is the presence of a pre-formed sac, there are certain subsidiary factors which are important in so far as they may be responsible for contents passing into the lumen of the sac. Speaking generally, any condition which increases intra abdominal pressure will come under this heading, the subsidiary factors will therefore include excessive crying, constipation, straining owing to a tight phimosis, and coughing.

The importance of these secondary factors is greatest in the new born child. There is no doubt that in a large proportion of children the processus vaginalis is incompletely occluded at birth, but the natural tendency to closure continues for some weeks, so that by the time the infant is a few months old the closure is complete, and the risk of a hernia abolished. If, however, during the period while the post natal closure is proceeding, any cause of unusual increase of intra abdominal pressure should exist, the likelihood of a hernia developing is apparent.

The Influence of Age Some years ago we investigated the question of the influence of age in relation to the period at which the hernia first became apparent. The following table is taken from that report:—

<i>Period at which Hernia was first noticed</i>	<i>Total Number</i>	<i>Males</i>	<i>Females</i>
Hernia present at birth	112	104	8
first seen during 1st month	142	138	4
2nd	125	113	12
3rd	74	68	6
4th	21	20	1
between 4th and 6th months	35	33	2
6th and 12th months	55	49	6
1 and 2 years	36	24	12
2 and 3 years	13	7	6
3 and 4 years	11	4	7
4 and 5 years	2	1	1
5 and 12 years	17	6	11

have extended through the external ring, and by the ninth month they reach the scrotum.



FIG. 403B — Dissection of Fœtus 6 months old.
The testis is just disappearing through the Internal Abdominal Ring.

The process is well described by Keith in the following words :—

‘ It will thus be seen that the Gubernaculum testis is an actively growing mass of fibro-cellular tissue, which, starting from the muscular structures of the mesorchium and plica gubernatrix in

dition is responsible for the abnormality in the nature of the hernial sac. Well recognized varieties of these unusual cases are —

- (1) An extroversion of the bladder complicated by inguinal hernia which is of the *direct variety*
- (2) Undescended testis accompanied by an inguinal hernia, in which the sac takes up a *pro parietal position*
- (3) Ectopia testis, in which the sac of the hernia follows the position of the misplaced testis

The Pathology of the Oblique Type The hernia sac in this variety leaves the abdomen in company with the various structures of the cord, courses through the abdominal wall along the inguinal canal, and appears on the surface through the external abdominal ring.

The Position of the Sac in the Cord As the sac lies within the interior of the cord it occupies a constant position therein, and it is of importance to realize the exact relationship of the parts, as a successful operation in the child depends on this knowledge. The sac lies in the middle of the cord, surrounded by its various coverings, the veins resting on its antero lateral aspect while the vas deferens with its artery lies on the postero median surface. The position is presented in Figures 410 and 411, and the detail is referred to again when the operation is discussed.

In the child the individual coverings are easily distinguished. The cremasteric layer is usually thick, with well developed muscular fibres, the internal spermatic, while easily separated, is extremely thin and to a beginner its presence may be almost unrecognizable.

The Occurrence of other Structures in the Cord In addition to the sac, various structures may be found on dissection of the cord. Yellow oval structures the size of beans may be recognizable—they are remains of adrenal tissue (cortical), which probably have become detached from the main adrenal capsules during the process of testicular descent. Other relics are derived from the Wolffian tubercles and on rare occasions small cysts, the size of a large pin head, are met with, these are lined with epithelium, and probably owe their origin to the inclusion at an early date of the various body layers.

At the upper extremity of the cord a pedunculated collection of



FIG. 404 — Large double direct Inguinal Hernia associated with imperfect descent of the Testes and an Epispadias

It is interesting to notice that in by far the largest proportion of cases the hernia originally appears in the first three months of life, the statistics thus supporting the theory of the congenital origin.

The Influence of Sex. The subject of inguinal hernia in the female is discussed under a separate heading, but it is interesting at this stage to compare the influence of sex. In the Edinburgh investigation already referred to, 1,000 cases were observed with the sex distinction in view. The results were as follows :—

Male cases	.	.	.	.	.	.	906
Female cases	.	.	.	.	.	.	94

which in percentage corresponds to males 90 per cent., females 10 per cent. These figures are relatively in agreement with those of other publications.

The Influence of Heredity. Some years ago Beiger published an analysis of hernia figures, and under the heading of 'the influence of heredity' he claimed that in a total of 7,542 cases 2,079 showed the influence of heredity, a proportion in fact of 1 in 3·6. Our experience has been very different—out of 1,000 cases in which careful inquiry was made only two instances were found in which there was any question of hereditary tendency. We believe therefore that the factor is of no etiological importance.

The Influence of a long Mesentery. The statement is sometimes made that abnormal length of the mesentery of the small intestine is a predisposing factor in the development of a hernia, assuming that a pre-formed sac exists. In our experience the matter is of no great significance.

The Side affected.

Right-sided inguinal herniæ are commoner than left-sided herniæ in a proportion of three to one. The following table shows the distribution in 1,000 cases.

<i>Side.</i>	<i>Number.</i>
Right	619
Left	244
Double	107
Position not stated	30

The explanation of a greater proportion occurring on the right side would appear to be that the right processus vaginalis closes at a slightly later period than the left.

THE PATHOLOGY OF INGUINAL HERNIA

In a descriptive account of inguinal hernia, distinction is usually drawn between the oblique and direct varieties of the disorder. Where the child is concerned the vast majority of the cases are 'oblique' in type, a small minority conform to other varieties, but it will be observed that these are cases in which a coincident pathological con-

to the muscular layer of the abdominal wall. This variety is usually associated with imperfect descent of the testis.

(2) *An Infantile Sac*

The testicle makes a complete descent, but in its progress, a diverticulum in connection with the fundus of the processus vaginalis remains attached in the region of the external ring, remaining as a long finger-like process, closed above but communicating below with the tunica vaginalis. In the course of time a partial closure of the real processus vaginalis occurs, but a funicular sac is left. The peculiarity of the infantile type therefore is that a process of peritoneum closed above, but communicating below with the space around the testis, lies in front of an ordinary funicular sac. The existence of apparently two distinct and separate sacs is a frequent source of confusion in operating on these cases.

(3) *The Encysted Sac* —*Hernia magna* (Russel)

If an anterior diverticulum occurs as described above, and if the processus vaginalis remains open throughout its length, the result is a type of sac which used to be spoken of as the encysted variety. The term 'encysted' was applied under a misapprehension regarding the method of formation of the hernia. It was thought that a hernia from above invaginated itself into a large tunica vaginalis, but since Russel has demonstrated the more probable mode of formation the term applied to the variety is that of 'hernia magna'. In view of the wide extent of sac which is available for contents, the size of this hernia may be very considerable indeed.

A convenient classification of the different varieties of sacs is as follows —



FIG 406 — Right Inguinal Hernia, funicular in type (Baby 1½ years old)

The outline of the testis is distinct from the hernia

fat is often present, especially in young stout babies. Its recognition is important in the operation of radical cure, and it should be borne in mind that sometimes a lateral projection of the bladder wall lies in close relationship to it.

The Forms which the Sac may assume. According to the extent and developmental variations of the sac (processus vaginalis), different varieties of inguinal hernia are recognized.

A. Sacs depending Primarily on an Error in Closure of the Processus vaginalis.

(1) The sac may be represented by a finger-like process which descends along the length of the cord, but does not communicate with the tunica vaginalis of the testis—the *funicular sac*.

(2) The sac may be continuous with the tunica vaginalis, so that testis and epididymis lie exposed in the fundus when the sac is opened—the *vaginal sac*.

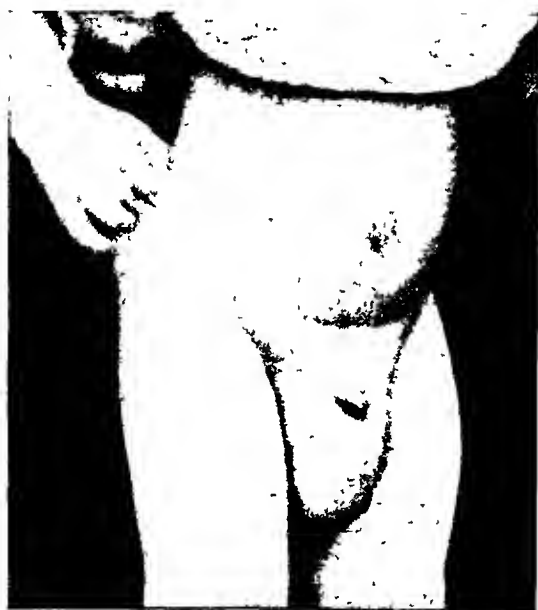


FIG. 405.—Double Inguinal Hernia (congenital)
(Boy 3 years old).

B. Sacs depending upon a Developmental Accident not primarily related to an Error in Closure. It is in connection with this group that so much controversy has arisen regarding the method of production of the sac and the nomenclature which should be applied to it. The late Mr. C. B. Lockwood and Mr. Hamilton Russel, of Melbourne, have written

largely on the subject. The description and classification of the latter writer are more generally accepted as expressing the correct position of affairs. As the processus vaginalis descends, a portion of the wall may become caught up in such a way that it is implicated in the developing abdominal wall, and, independent of what may happen to the processus vaginalis, a lateral diverticulum or additional sac is formed at the point of the attachment. Included under this possibility there are three varieties of saccular formation :—

(1) *An Interstitial Sac.*

It may be *pro-parietal* (*superficial*), *inter-parietal* (*intra-muscular*), or *retro-parietal* (*pro-peritoneal*) according to the relationship of the sac

of the testes, and the examiner satisfies himself that these organs are fully descended and in their proper position. If a hydrocele is present its relationship to testis and cord is defined. The next step is the examination of the cord and in the child this stage of the investigation is of great importance. The cord is picked up between the finger and thumb of the examiner's hand immediately below the level of the external abdominal ring, and

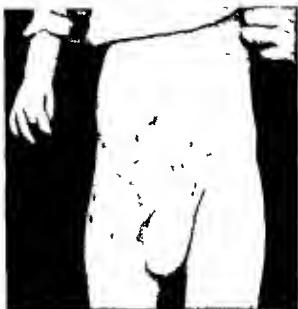


FIG 407 —Left Inguinal Hernia vaginal in type (Boy 2 years)

from within outwards the various constituents are allowed to slip through the examining fingers.

The inner edge of the coverings, the cord like vas, and the outer edge of the coverings are always definable. This stage of the examination is important because if the hernia is unilateral the presence of the sac is recognizable even though no contents are present. Even in a double hernia the trained investigator is able to recognize the abnormal thickness of both cords, though no comparison is possible as in a single case.

The finger is run along the whole length of the cord, and it may be possible to delimit the lower end of a funicular sac. Any localized swelling such as an encysted hydrocele is demonstrated at this stage of the examination. With the tip of the little finger the skin of the scrotum is gently invaginated, and the apertures of the external abdominal rings are investigated. A patulous



FIG 408 — Large right Inguinal Hernia vaginal in type (Boy 2½ years old)

The child shows many evidences of rickets

- A. Sacs depending primarily upon an error in closure of the *processus vaginalis*. { 1. Funicular sacs.
2. Vaginal sacs.
- B. Sacs depending upon a developmental accident apart from an error in closure. { 3. Interstitial
4. Infantile
5. *Hernia magna* (encysted).

The vast proportion of herniæ in children shows the funicular type of sac. In an examination of 1,000 cases, the various sacs were distributed as follows:—

Funicular sacs.	.	.	.	.	.	941
Vaginal sacs	.	.	.	.	.	48
Interstitial sacs	.	.	.	.	.	2
Herniæ magnæ	.	.	.	.	.	$\frac{1}{2}$
Infantile sacs	.	.	.	.	.	5

It is interesting to notice that the vaginal sac is more common on the right side than on the left in a proportion of 40 to 8.

Contents of the Sac. Small intestine is the most frequent content of the sac. On the right side, if the hernia is a large one, the cæcum and appendix are often present; we have found such in 56 out of 1,000 cases. Omental contents are uncommon in children, because at an early age the omentum has not reached the degree of development which it assumes in later life.

CLINICAL FEATURES

In certain cases the hernia is noticeable at birth, and some of the most extensive examples of the error come under this heading. In the majority, however, the hernia appears during the second or third month; there may have been a spell of crying, and the original appearance of the swelling is dated from that time. The hernia reduces easily, often disappears spontaneously when crying or straining ceases, and a long interval of time may elapse before it again becomes noticeable. A neglected case has a tendency to increase in size—the walls of the sac stretch, the natural openings of the abdominal wall become widened, and greater amounts of contents appear in the sac. The large herniæ which contain a quantity of small intestine and possibly the cæcum or sigmoid loop are associated with signs of intestinal derangement. There is constipation with intervals of diarrhœa, frequent colic, a loss of appetite, sickness, and a falling-off in weight. Some children show a good deal of irritability and nervous derangement. In certain instances there are bladder symptoms, such as frequency of micturition or incontinence. Pain is not a common clinical feature as far as one is able to judge. In the majority of cases the existence of the swelling is the only clinical feature.

PHYSICAL EXAMINATION

It is important that a definite routine be followed in the examination of every hernia case. The investigation begins with an examination

- (b) In the majority of cases it is possible to palpate a normal cord above the upper limit of the swelling. If the hydrocele extends through the external ring, this test will be inapplicable, but this is rare.
- (c) The swelling is movable both in the long axis and across the cord.
- (d) The hydrocele of the cord has a distinctive sensation on touch—it is tense, smooth in outline, and fluctuation can be detected in it.
- (e) The swelling shows no impulse on coughing.

II *Lipoma of the Cord*

At the inner side of the neck of the sac there is normally a small pedunculated collection of fat. Under certain conditions this portion of fat enlarges and elongates, and extends along the cord in very much the same position as a hernia sac. The following characteristics may help to distinguish it, though its exact recognition may be extremely difficult —

- (a) The swelling is constantly present.
- (b) There is an absence of impulse on coughing.
- (c) The swelling occupies a position on the inner side of the cord, and it may be possible to differentiate the cord from it.

III *Intermittent Hydrocele of the Tunica vaginalis*

In a case of ordinary hydrocele there is very little likelihood of a mistake arising, because the swelling lies entirely below the examining fingers when the spermatic cord is grasped. There is difficulty, however, in the case of the *intermittent hydrocele*, because, in addition to the hydrocele of the tunica vaginalis there is an incomplete closure of the processus vaginalis, the degree of patency being too small to permit of a hernia, yet sufficient to allow fluid to pass from the abdominal cavity into the tunica vaginalis. There is a history of an intermittent swelling, and on examining the cord an increase in its size is detectable. These two features at first sight would seem to suggest a hernia, but the following points indicate the true nature of the condition —

- (a) It is obvious that whatever else exists a hydrocele is present.
- (b) The size of the hydrocele varies from time to time, pointing to a communication with the abdominal cavity.
- (c) Though a thickened cord is demonstrable, its girth is never increased by the presence of contents passing into it from above.

IV *Undescended Testis*

An undescended testis may be mistaken for a hernia. The mistake is avoided by careful examination of the scrotum, but the surgeon is aware that the majority of cases of undescended testis are complicated by the presence of a pro parietal or superficial hernia. If an

external ring is suggestive of a hernia being in existence on that side.

Examination of the canal is inadvisable in the child. No knowledge of practical value is gained; in fact, damage may be done if an attempt is made to introduce the finger into the canal.

It is possible that during the course of the examination the hernia becomes more definite owing to contents passing into the sac. A further appreciation of its extent is then possible, and the size will vary from the small compass of the bubonocoele to the comparatively enormous area of the hernia magna which may actually envelop and obliterate the outline of the penis.

If contents are present, an estimation is made of their possible nature—enterocoele (intestine), or epiploicele (omentum); sometimes an appendix can be palpated among the contents of a large inguinal hernia. As the contents are reduced, such points as ease, difficulty, or incompleteness in reduction are noted.

THE DIAGNOSIS OF INGUINAL HERNIA IN THE MALE

There is rarely much difficulty in the actual diagnosis; a reducible swelling which passes from above downwards and makes its appearance on the surface through the external ring is unlikely to be anything other than a hernia. The chief difficulty arises in those cases in which contents are not present in the sac at the time of examination. Under such conditions attention must be paid to the history, but too much importance should not be attributed to it, because in the lay mind any swelling in the inguinal region ranks as a 'rupture.' As far as the physical examination is concerned the surgeon attaches importance to the investigation of the cord and the external rings. An enlarged cord is suggestive of a hernia sac being present among its constituents, and, if comparison is possible with a normal cord on the opposite side, the observation is peculiarly valuable. A patulous ring on the same side as the enlarged cord indicates that contents are frequently passing into the hernia sac.

The Differential Diagnosis. There are certain conditions which may offer difficulty in so far as they are sometimes mistaken for inguinal hernia.

I. Encysted Hydrocele of the Cord.

A child presents a localized swelling in the line of the spermatic cord, which is obviously incorporated with the cord, and is irreducible. Such a condition, indicative of a hydrocele of the cord, is frequently mistaken for an irreducible hernia.

A case of this description has certain characteristics which suffice to distinguish it:—

- (a) The swelling is irreducible, yet there are none of the symptoms which are associated with an irreducible hernia.

In regard to the aim of conservative treatment it should be made clear to parents that the method has certain limitations. It should be pointed out that in children over three months old the method does not hold out the prospect of cure—it leads to apposition of the sac surfaces, but, under any unusual increase of intra abdominal pressure, the hernia is liable to reappear. To secure any benefit, the truss treatment must be constantly followed, and great care must be exercised in the method of applying the truss.

Trusses

Varieties and Methods of Application A well fitting truss is the essential of an efficient conservative treatment, and therefore we have to consider the various appliances which may be used.

The Worsted Truss During the first six months of life the worsted truss is an excellent and efficient appliance. It has many advantages, it is cheap and easily procurable, it does not tend to produce excoriation of the tender skin of the baby, and, if properly applied, it is as efficacious as a more complicated appliance.

The method of its application is as follows a half skein of four ply white Berlin wool is procured. The child is placed supine, and the hernia is reduced, the skein is hooked round the thumb of the surgeon's left hand, and the tip of the thumb is placed over the ring so as to prevent contents appearing in the sac. The other end of the skein is passed round the side on which the hernia exists underneath the back and across the front of the body to where the thumb is resting over the ring. The free end of the skein is now passed through the loop which is being held in place by the thumb, and the bunch of wool produced by the looping is carefully adjusted over the external abdominal ring, the thumb being removed when this is completed. It is sometimes advised that, in addition to looping one end through the other, an actual knot should be made. The free end is now passed under the leg, and fastened to the circular band at the back.

The success of the method depends upon the intelligence of the mother, and the care with which she carries out instructions. The truss should fit snugly, and it must be worn night and day. Whenever it is to be changed the child must be down, it should not be removed while the child is struggling or crying, and while the truss is out of position pressure with thumb or finger should be maintained over the external ring in order to prevent contents passing into the sac. This fact especially should be impressed on the mother—to permit contents to pass into the sac on even a single occasion will undo all the benefit of months of careful conservatism, and a treatment which may have been almost successful has to begin afresh.

The Sponge Truss This is an excellent appliance for use in babies. A circular rubber sponge, measuring $2\frac{1}{2}$ inches in diameter and $1\frac{1}{2}$ inches in depth, is fastened to a piece of broad webbing bandage. The webbing is so arranged that when in position the sponge is situated

undescended testis is present, careful examination of the inguinal swelling in reference to consistency and tenderness will disclose its nature. The tumour of a hernia is elastic and painless on pressure, while that of an undescended testicle is firm and tender.

THE TREATMENT OF INGUINAL HERNIA

Does a Natural Cure ever Occur ?

Where children are concerned this question is one of considerable importance. Many children are born with a patent processus vaginalis, in whom it is demonstrable that an attempt at natural closure has proceeded up to a certain point. The attempt is apparent in the area of thickened tissue which surrounds the hernia sac as a dense white ring. Such being the case, the question is asked—is it not possible so to arrange matters that the tendency to natural closure is encouraged for some months after birth ? Undoubtedly an affirmative answer should be given. If a hernia is detected at birth the adoption of certain precautions may lead to a post-natal closure of the sac, and a natural cure of the hernia. This point, however, must be made clear—such a possibility is only feasible during the first three months of life. The steps which should be taken to encourage a natural cure are as follows :—

(a) The baby should be nursed with the head and upper body in a slightly dependent position—this applies especially to the position of cot or cradle.

(b) Every care should be taken that no cause of excessive straining exists. Anything which leads to an increase of the intra-abdominal pressure will inevitably result in an opening up of the sac ; therefore attention should be paid to such errors as constipation, phimosis, balanitis, cough, or excessive crying.

(c) A small worsted truss should be applied in the manner to be described, the pad of the truss exerting constant pressure over the region of the external ring.

The essential aim of these measures is that for a period of three months after birth every precaution is taken to ensure that no opening up of the hernia sac occurs. After this period has elapsed, if a recurrence of the hernia appears, no further hope of a natural cure need be entertained.

Conservative Treatment or Operative Treatment ?

There are probably few who would venture to contradict the statement that the operative treatment of hernia in children is extremely satisfactory. Yet there are certain conditions under which a conservative line of treatment is advisable. It is advisable—

- (1) *During the first three months of life ;*
- (2) *During the period of teething ;*
- (3) *If the child is a feeble diminutive infant.*

accurately to the pelvis along the line which the truss will follow. To permit removal while retaining the correct outline, the tape should be in two portions, being interrupted in the mid line by a movable joint of strong sticking-plaster.

The Wearing of the Truss The parents are directed that the truss should only be applied when the hernia is fully reduced. At the area where pressure is being exerted the skin is kept in good condition by the application once daily of methylated spirit and dusting powder. When the truss is removed, care must be taken that no contents pass into the sac, and as when the child is at stool there is a tendency for even the best-fitting truss to be displaced upwards, care should be taken to readjust it after this event.

The question arises as to what is to be done when the child has a bath. Babies and small children may be sponged while they lie on their backs, and during that time the hernia should be controlled. With older children the question is more difficult, it is unwise to risk the romping which is inevitable at bathing time unless some means are taken to guard against contents appearing, at this time a *water proof celluloid spiral spring truss* should be used.

Children stand truss treatment badly, the care which it entails becomes irksome and intolerable, and when school age is reached there are comparatively few children who can be persuaded to continue it.

The Operative Treatment

At the present time the great majority of children who suffer from hernia are operated on. The advantages of operation are obvious: the method is simple, rapid, and safe, it is eminently satisfactory in so far as any tendency to recurrence is concerned, and all the irksomeness and inconvenience of truss treatment are avoided. In fact, one may say that except where some strong contra indication exists, the tendency at present is to urge that a radical cure be carried out in every case of inguinal hernia in the child.

CONTRA INDICATIONS TO OPERATION We have already mentioned the indications for conservative treatment. Two of these are questions of the most suitable age rather than contra indications, the third is the only real bar to operation—the operation should not be carried out if the child is suffering from any general illness, or local infected condition.

The most suitable Time for Operation There are three periods in a child's life which are the most suitable for the performance of the operation. They are —

- (1) Between the third month and the time when teething begins
- (2) At the end of the second year
- (3) Immediately before the child goes to school

The reasons for choice of these periods are obvious. Up to the third month there is the possibility of natural closure of the processus, from

over the affected external ring. To the front of the webbing opposite the sponge a broad elastic tape is secured, which, passing through the perineum, is secured to the circular band behind.

Other Varieties of Trusses. We believe that it is a mistake to employ a *spring truss* in the early years of life. To be efficacious the spring must have a certain degree of strength, and the constant pressure which it exerts leads to an atrophy of the thin abdominal muscles of the child. On several occasions we have seen a true ventral hernia develop in the situation of the external ring from the long-continued pressure of a spiral spring adder-headed truss. In the first six months of life we advise a *worsted truss*. If for any reason this is unsuitable, we recommend an *inflatable rubber truss*. This appliance is comfortable and efficacious, but it has two disadvantages—it is expensive, and the rubber soon tends to stretch and perish. Rubber trusses may be worn until the end of the second year. From the second year onwards, we advise the use of a *moc main truss*. In this variety there is no spiral spring, and the soft leather band around the waist produces no discomfort. Pressure on the ring is secured by means of a circular pad, a vertical spring, and a band.

In children above the age of seven years a *spiral spring truss* may be worn with less risk than at an earlier age, but we believe that, if possible, this type of appliance should be avoided. If a spring truss is required, the type which most fully meets the requirements is the *cross body or Hood truss*. It consists of a pad with a metallic spring surrounding two-thirds of the pelvis, and supplied with a strap which completes the circumference by being buttoned to the pad.

De Garro has modified and improved this truss by substituting for the steel spring one of German silver covered with hard rubber. This material is easily shaped, and it exerts a light but efficient pressure.

MEASURING FOR A TRUSS AND GENERAL DIRECTIONS FOR ITS USE. Instrument makers recognize a routine measurement, and, in ordering a truss, if personal fitting is impossible, the regulation plan should be carefully followed. The line extends from the spine of the pubis on the affected side midway between the crest of the ilium and the tip of the great trochanter, across the base of the sacrum, midway between the crest of the ilium and the tip of the great trochanter of the opposite side to end at the point of commencement. This measurement is supplied, indicating the side affected, and the type of truss which is desired. It is essential that the truss should be a well-fitting one—irritation and excoriation are intolerable to the child—no extra padding of the spring or pad should be permitted, and therefore accurate fitting is essential.

Shaping the Truss. Where spring trusses are concerned it is essential that the spring be accurately fitted to the child's body; only thus will excoriation be avoided when sufficient pressure is exerted to hold the hernia in place. The fitting is facilitated if an outline of the child's body is first obtained by the use of a soft lead tape, which is moulded

tearing the delicate spermatic plexus of veins. There is one method by which the sac is easily secured. Remembering that the sac lies in the interior of the cord with the vein on its antero lateral aspect, and the vas deferens with its vessels on the postero medial aspect, the cord with its coverings is stretched out in such a way that its antero lateral aspect is uppermost. Artery forceps applied to opposite edges of the cord will secure this position, and the forceps being applied as low down on the cord as possible, the cord is stretched out in a fan shape, the handle of the fan being at the position of the external ring. An incision is now made into the coverings of the cord along the middle of the fan shaped area. This incision divides what there may be of the external spermatic fascia and the entire thickness of the cremasteric



FIG. 403.—Operation for Radical Cure of Inguinal Hernia
Exposure of the Cord

fascia. The latter retracts on division, and if the incision has been planned correctly, the plexus of spermatic veins now comes into view. It is important to realize that the veins cannot yet be separated, because they are covered by the thin layer of internal spermatic fascia. A further light incision to one side of the veins divides this covering, and it is now possible to pick up the veins, and, with blunt dissecting forceps, to strip them inwards together with the internal spermatic fascia. The structure from which the veins are stripped is the hernia sac. The appreciation of this detail is essential if the operation is to be a satisfactory one, and to the beginner its recognition will make all the difference between success and failure. The sac is now picked up in the forceps and its separation is begun. The forceps

the sixth month until the end of the second year there are the disadvantages of teething ; and the period before school age is chosen because if the child is to mix with other children and to indulge in their games, it is wise previously to correct the hernia error.

The Operation

Pre-operative Precautions.

Precautions are taken as before all operations in children. If a phimosis is present a circumcision should be done and the wound healed before operation on the hernia is undertaken. There must be no point of excoriation or sepsis anywhere in the neighbourhood of the wound. The urine should be examined for the presence of acetone, and the appearances of these substances should be taken as an indication to delay operation until the error has been counteracted.

The Operative Procedure.

The operation which is performed on the child differs in certain important details from that which is carried out on the adult. The circumstances which modify the procedure in the case of the child are : (1) The error is a congenital one, a pre-formed sac is the cause of the hernia, (2) there is no weakness in the musculature of the inguinal canal, and (3) the length of the inguinal canal is so short that without opening up the canal to any extent it is possible by tension on the sac to bring the internal ring into view. In view of these peculiarities it is never necessary to open up the inguinal canal of the child as it is in the adult.

The operation which the majority of surgeons perform is based upon the method which was described many years ago by Mitchell Bankes of Liverpool. The procedure is as follows : a flat pillow is placed below the buttocks so as to slightly elevate the pelvis. An incision about 1 inch long is made over the situation of the external abdominal ring in the line of the cord. Bleeding occurs from two small vessels which are remarkably constant in their position, the superficial external iliac, and the superficial epigastric. The dissection is deepened until the aponeurosis of the external oblique is exposed, the split in its fibres indicating the position of the external ring is defined, care being taken not to destroy the inter-columnar fibres which cross the divarication. Immediately above the ring the inguinal branch of the ilio-inguinal nerve may be exposed as it pierces the aponeurosis. The cord now comes into view as it appears on the surface at the lower end of the ring ; it is gently separated from its bed and lifted into the wound, and with a few touches of a sharp knife the edges of the external ring are more clearly defined. The secret of a successful operation depends upon the isolation of the sac as it lies in the centre of the cord, and this should be done without much disturbance of the other constituents, and especially without

assured that it is as high as is necessary To the inner side of the neck of the sac, a small diverticulum of extra peritoneal fat may come into view This is detached by a delicate stroke of the knife, and its separation is completed by stripping with a piece of gauze This step is essential, as otherwise a small potential sac may remain

When the operator is satisfied that he has reached as high a limit of separation of the sac as is possible, and has assured himself that no contents are present within the sac, he transfixes and ligatures the sac neck with catgut The portion of the sac beyond the ligature is cut

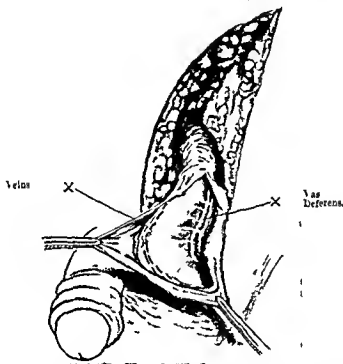


FIG 411 —Operation for Radical Cure of Inguinal Hernia

The sac has been turned inwards so as to expose the vas deferens with its accompanying vessels

away, and when the ligature is divided the neck retracts through the abdominal wall to a position flush with the parietal peritoneum It is to secure this complete retraction that it is so important for the assistant to maintain steady traction on the sac until the ligature is applied and the sac removed Imperfect retraction will mean the persistence of a dimple at the position of the internal ring and the possible recurrence of the hernia

With removal of the sac, the essential steps of the operation are concluded, it is the common practice, however, to insert one or more sutures so as to narrow the external abdominal ring These sutures are of catgut, and they are most conveniently inserted with a needle-

which grasps it should be held in the left hand, and, as the separation is proceeded with, the sac is gradually turned inwards towards the middle line until the posterior surface, with the vas deferens attached to it, is exposed to view. The vas with its accompanying artery is now separated.

Having assured himself that the sac is empty, the operator grasps it in the bite of artery forceps at as low a level as possible, and divides it below the forceps. The lower portion, the fundus, is examined in order to ascertain whether it is funicular or vaginal in type.

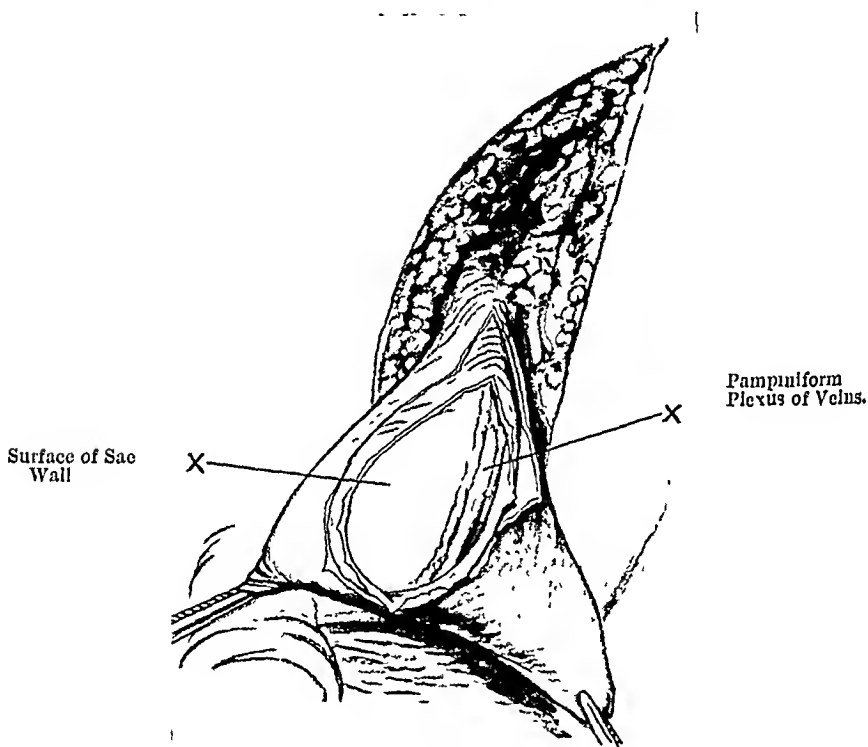


FIG. 410 —Operation for Radical Cure of Inguinal Hernia.

The cord is held taut by forceps applied laterally—the coverings have been divided and the pampiniform plexus is apparent

It is a mistake to attempt to remove in part or in whole the lower end of the sac. Its removal is associated with bleeding which may be difficult to arrest, and no harm is done by leaving it *in situ*.

Attention is now paid to the upper end of the sac. An assistant holding the forceps, the sac is kept taut while the operator picks up in turn the spermatic veins and the vas, and dissects them free from the sac to as high a level as possible. Particular care is demanded in separating the vas, as it is so easily divided by a misdirected incision. The assistant continuing to exert steady traction on the sac, the inferior epigastric vessels become apparent as they cross the inner side of the neck, and, if the parts are freed to this level the operator may be

almost certain to ensue. The dressings are constantly wet with discharged urine, frequent changing is necessary, and as a result sepsis frequently follows. Now sepsis of a hernia wound is an exceedingly grave complication, and to avoid such a risk it is wiser in babies to leave the wound unprotected except for the application of an anti-septic paste or powder. In the Edinburgh Children's Hospital it has

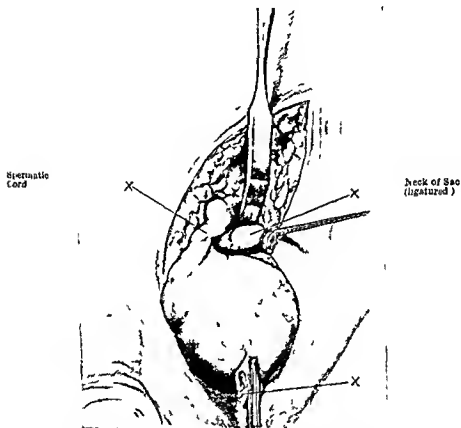


FIG. 413.—Operation for Radical Cure of Inguinal Hernia

The sac has been transected by a ligature at its neck, and after the ligature is cut the neck will retract within the inguinal canal.

been the practice for a number of years past to smear over the fresh wound a paste composed as follows —

Iodoform	1 part
Bismuth subnitrate	2 parts

The components are thoroughly mixed in a sterile mortar, and the resulting mixture is transferred to a receptacle which is filled with 1 in 1,000 corrosive sublimate. The paste is applied to the wound surface as often as is necessary.

holder and round fistula needles. The cord having been replaced in position, each suture passes through the edge of the inguinal ligament on the outer side and the conjoined tendon and inner pillar of the ring on the inner side. Care must be taken that the ring is not closed too tightly, or harmful pressure may be exerted upon the cord. After

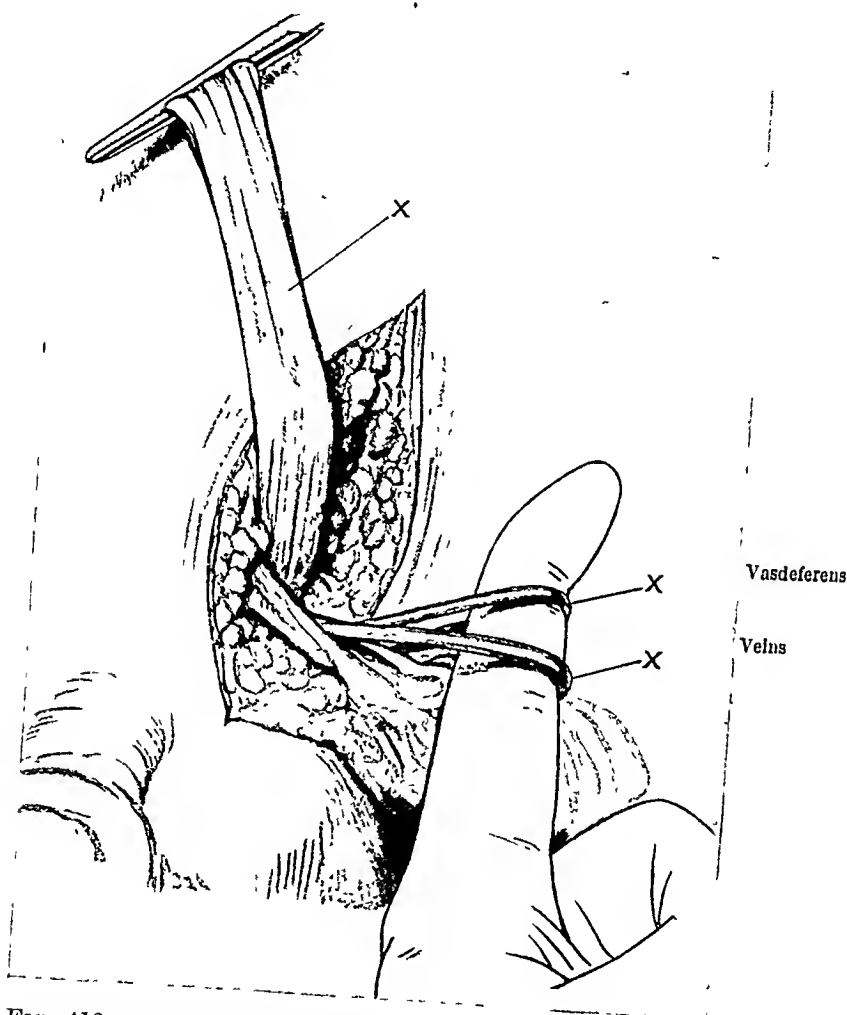


FIG. 412.—Operation for Radical Cure of Inguinal Hernia.

The sac has been separated and is held upwards in forceps. The veins and the vas deferens are isolated on the fingers for demonstration, but this is not a part of the regular technique.

the vessels are ligatured, the skin wound is closed by a mattress suture of silkworm gut and Michel's clips.

The Dressing to be Applied.

In children beyond the age of infancy there is no difficulty about the dressing, sterile gauze, wool and bandage being used as in the adult, but with babies, if the usual method is employed, disaster is

- 3 Scrotal hæmatoma
- 4 Torsion of the cord
- 5 Postural hæmaturia

1 *Sepsis* This is a most unfortunate complication, and in young infants it may be a most serious one. The infection rapidly spreads to the groin glands and into the scrotum, it may lead to sloughing of the testis on the affected side, and not infrequently it has a fatal termination.

One of the most fertile causes of sepsis is the covering of the hernia wound of a young infant with a quantity of dressing material and wool. Sepsis is almost unknown if the 'open' system is employed.

When sepsis occurs the wound must be freely opened up, and a moist antiseptic dressing applied.

2 *Injury to Bladder or Bowel* These complications may occur when the neck of a large sac is transfixed. If the bowel is injured it is due to carelessness on the part of the operator, as it is a perfectly avoidable accident, but injury to the bladder may be sustained even if great care is taken. The danger lies in mistaking the bladder wall for the collection of fat which normally lies at the inner side of the neck. The accident is avoided by ensuring that the neck of the sac is free from an extra saccular attachment before transfixion is carried out. If the bowel is injured a laparotomy must be performed, and the damaged loop found and repaired. This complication is naturally a very serious one, associated with a high mortality. It will be evidenced by symptoms of obstruction, followed, in most cases, by the signs of a spreading peritonitis.

Injury to the bladder wall is less serious. It is evidenced by hæmaturia and in certain cases by an extravasation of urine into the deeper parts of the wound. When the complication is recognized it is at first treated by temporizing measures, the bladder being drained 'per urethram'. Certain cases recover without developing any sign more serious than the hæmaturia. If there is extravasation of urine (and it almost certainly will be an extra peritoneal extravasation), it is most efficiently treated by drainage through the hernia wound. The fistula does not persist for any length of time.

3 *Scrotal Hæmatoma* It is exceedingly annoying to find that a large post-operative hæmatoma has developed and has filled the scrotum on the affected side. The complication encourages sepsis, and even if this does not supervene, a long period of time elapses before the swelling subsides. The hæmorrhage proceeds from the pampiniform plexus, and therefore every care must be taken to arrest hæmorrhage from this source during the operation.

If the hæmatoma is large it is advisable to administer an anæsthetic to open up the wound, and to clear out the clot.

4 *Torsion of the Cord* After the operation for hernia the surgeon sometimes finds that the testis becomes swollen and œdematous to a

The Cot Arrangements.

The cot upon which the baby is to be nursed requires special preparations. A diaper is spread beneath the pelvis, and upon it the fæces are collected. A small cage is arranged over the child, and from its lower end a piece of sterile lint hangs down on to the front of the child's thighs, so that when urination takes place the urine is caught by the cloth and soaking is prevented. The cloth is changed when wet. To each ankle a small padded clove hitch is attached, and fastened to the lower corners of the cot. The arms are slipped through slits in a broad chest band, the ends of which are pinned to the sheet. By this arrangement, while movements of the hands and forearms are permitted, the child cannot finger the wound. Around the lower edge of

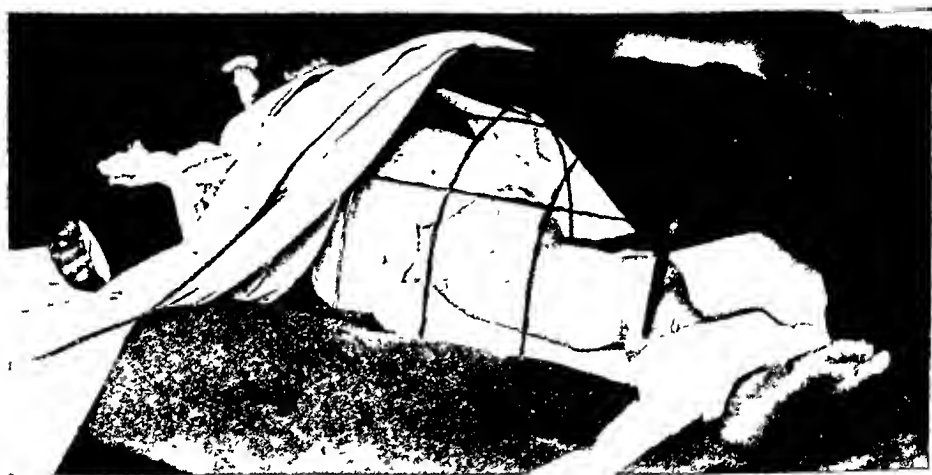


FIG 414.—The Technique of the Post-operative Care of a case of Inguinal Hernia.

No dressing is applied, and the precautions taken to prevent contact with the wound are illustrated.

the bed jacket or binder which the child wears, a sterile towel is pinned in case the edge should come in contact with the wound.

If a routine such as this is followed, the post-operative treatment is comparatively easy, and even in the youngest child there is no risk of sepsis supervening.

If a mattress stitch has been used it is removed in forty-eight hours; Michel's clips are removed on the fourth day, sutures on the fifth or sixth day.

Post-operative Complications. The operation is an eminently satisfactory one, and it is rarely that any post-operative complications occur. Certain of those included in the following list are almost hypothetical, their occurrence is so rare :—

1. Sepsis.
2. Injury to bladder or bowel.

through a narrow external ring, and in the large old standing hernia, in which an extensive sac accommodates a quantity of omentum or intestine. In this latter variety, if the hernia is on the right side with the cæcum present in the sac, irreducibility is a comparatively common event. The complication is liable to occur in the more uncommon types of sac—interstitial, infantile, and hernia magna.

One is accustomed to ascribe certain peculiarities to the irreducible hernia of the child which to some extent distinguish it from the adult condition.

- 1 Even if intestine is present in the sac the child may show no sign of an obstructive nature
- 2 Reduction is practically always possible if relaxation of the abdominal musculature can be secured
- 3 Adhesions between sac and contents are uncommon
- 4 Irreducibility rarely leads to strangulation of contents

TREATMENT OF AN IRREDUCIBLE HERNIA

As a rule it is wise to accept irreducibility as an indication for operation. Under the following conditions operation becomes imperative —

- (a) If efforts at reduction have failed
- (b) If signs of intestinal obstruction are present
- (c) If there is reason to suspect that strangulation is ensuing
- (d) If the sac is one of the abnormal varieties in which a secondary diverticulum exists

A small irreducible hernia is more dangerous than a large one, because it is more liable to undergo strangulation.

In the absence of indications demanding operation, a conservative line of treatment may be followed. In babies and young children a general anæsthetic should be administered in order to ensure complete muscular relaxation. Attempts at reduction while the child is crying and struggling are certain to end in failure, and in many cases harm is done to contents by the force which has been exerted. If, in spite of anæsthesia, irreducibility persists, operation becomes imperative.

In attempting reduction, the contents which occupy the posterior part of the sac are returned first, and reduction is proceeded with from the posterior to the anterior part. This is but the application of the rule that the contents last prolapsed should be returned first. Spitzzy recommends a method of taxis which he has found of great value. The patient is placed in a warm bath and light narcosis is induced with ether. Lifting the patient by the legs and allowing the body to hang, the scrotum is pulled taut and an attempt is made to shake the contents of the sac back into the abdominal cavity. This position favours the co-operation of all the natural forces—the relief of congestion, the influence of gravity, the pull of the mesentery, and above all it has the advantage that it renders unnecessary any direct

much greater extent than is explicable by simple manipulation of the parts. He is further distressed to find that the enlarged testis passes on to atrophy of the organ. The explanation is simple—the swelling is the result of an artificial torsion of the cord. When the hernia sac has been separated the testis has prolapsed from the scrotum; in the subsequent manipulation the cord has become twisted, and when the testis is finally returned to the scrotum an additional twist is added. A true torsion has been artificially induced.

A somewhat similar swelling of the testis and epididymis occurs if the external abdominal ring is narrowed too much by sutures. In both cases knowledge of the possibility of the complication will lead to its avoidance.

5. *Postural Hæmaturia*. This complication has been alluded to before. It is more liable to occur after operation for hernia than after many other procedures, because the child is kept so rigidly in the supine position. It is important to remember the possibility of its occurrence, or the hæmaturia may be ascribed to an operative injury of the bladder.

No special treatment is indicated. Quantities of bland fluids are given by the mouth, and, as soon as possible, the patient is allowed to relinquish the supine position.

Results of the Operation. From whatever standpoint it is judged the operation must rank as one of the most satisfactory in surgery. The mortality is extremely low. In the last 1,000 operations performed at the Edinburgh Children's Hospital there were three deaths. The following table shows the causes of the mortality:—

Mortality in 1,000 Cases:—

Broncho-pneumonia	.	.	.	.	2 cases
Convulsions	.	.	.	.	1 case

If judged from the point of view of recurrence the results are equally good. If the hernia sac is properly isolated and secured, recurrence is practically unknown. The only instances which the author has seen have been examples of strangulated hernia in young babies. The original operation demanded division of muscles in order to relieve the strangulation, and several of these cases required subsequent operation on account of a small acquired secondary hernia.

The Complications of Inguinal Hernia

When one considers how common inguinal hernia is in children it is remarkable how rarely one meets with complications of the condition. Sooner or later, however, the clinician meets with one or other of three complications—irreducibility of contents, strangulation of contents, and tuberculosis of the hernial sac.

Irreducibility. There are two varieties of hernia in which irreducibility is liable to occur—in the small hernia which is appearing

ring is now divided from without inwards, every care being taken to avoid injury to the sac at this level. A tear in this situation tends to spread upwards, and it may be exceedingly difficult subsequently to repair the defect. It is well to divide the constriction upon a director inserted between the sac wall and the muscular aponeurosis. The division of the muscle should be as limited as possible in order to minimize the damage to the inguinal canal. While the constricting tissue is being divided, control should be maintained over the prolapsed bowel, it is an unpleasant experience to expose a loop of questionable viability, and to find it disappear into the abdomen before one has had an opportunity of satisfying oneself of its condition. In many cases a constriction in the form of a fibrous ring is found to exist in the sac wall; this impediment is divided or stretched from within the sac lumen. We have already indicated how rare is the occurrence of necrosis of the bowel wall. It may be that there are localized areas of suspicious vitality, and these are invaginated by a circular or Lembert suture. If a loop of bowel is in such a condition that its viability is a matter of grave doubt, one is naturally faced with the question of carrying out resection, but, in view of the fact that the mortality from this procedure in children is considerable, it is better, if the least doubt exists, to give the bowel the benefit of that doubt and to return it within the abdomen. When replaced in its natural surroundings the most doubtful bowel wall often makes a remarkable recovery. If extensive and undoubted gangrene is present, immediate resection is preferable to an enterostomy.

TUBERCULOSIS OF THE HERNIA SAC

In the presence of tuberculous peritonitis, or even independent of this condition, it may happen that tuberculous disease affects the peritoneum of the processus vaginalis. Clinically the condition is evidenced by an unusual degree of thickening of the sac wall, and by the presence of fluid—free or encysted—within the sac.

When exposed, the interior of the sac wall is found to be studded with plaques and tubercles, the tuberculous nature of which is revealed by microscopical examination. The condition is one of considerable clinical importance, it suggests an abdominal lesion which may previously have been overlooked; the thickened sac may be confused with the complications of irreducibility or of strangulation, and it is the only variety of juvenile hernia which is likely to show adhesion between sac walls and contents.

When the condition is met with, operation should be recommended for the reasons that the disease may spread to the testis, epididymis, and even to the tissues of the scrotum, and that eventually the hernia contents will become irreducible.

The operation is similar to that performed for uncomplicated hernia. Separation of the sac may be difficult and every tuberculous sac should be opened in case adherent contents are present. The neck of

pressure on the contents. If reduction has been secured, precautions are taken that contents do not again prolapse, and for this purpose the application of a large sponge truss is the best procedure.

If reduction under anaesthesia has failed, and until arrangements are made for an operation to be carried out, the child should be returned to bed. The foot of the bed is well elevated, a large warm soothing fomentation is applied over the tumour, and the child is given a dose of chloral and bromide mixture.

Strangulation. It is fortunate that true strangulation is exceedingly rare in children. Estoei¹ instituted an elaborate enquiry into the matter, and after consulting hospital records at Basle, Prague, Breslau, Vienna, Krakau, Frankfort, Amsterdam, Berne and Göttingen, he found that among 139,000 examples of hernia in children there was not a single record of herniotomy having been done for strangulation.

In an analysis of 10,000 cases at the Edinburgh Children's Hospital there was no instance of complete strangulation and resulting gangrene of a loop of intestine, such as is met with in the adult. Out of the total series there were fourteen cases of irreducible hernia in which there was sufficient interference with the blood supply of the contents to justify the qualification of strangulation, but even in the most extreme instances the vascular change had resulted in localized patches of necrosis, and these were at points such as the external ring, where unusual pressure had been exerted. It is rarely indeed that the necrosis is so extensive as to call for resection of the prolapsed bowel.

It has been our experience that strangulation of the juvenile hernia is most common in the first year of life. Out of fourteen cases thirteen occurred during the first year, the only exception being in a child of 1½ years, and moreover ten of the cases occurred during the first six months of life. We believe that the early incidence of the complication is related to the attempt at natural closure of the processus vaginalis. The fibrous ring, the local evidence of the attempt, is the constricting factor which produces the strangulation.

TREATMENT OF A STRANGULATED HERNIA

On the occurrence of this complication, operation is obviously imperative. In children the operation has certain distinctive features. Atropin is administered beforehand, and gas and oxygen is the anaesthetic of choice. If there has been vomiting, the stomach should be washed out and the lower bowel emptied by a small simple enema. The usual hernia incision is deepened until the external ring is exposed. Through it the hernia, incorporated with the tissues of the cord, protrudes. The sac is isolated as in the method previously described, its lumen is opened, and the contents brought into view. The constriction which exists at the situation of the external abdominal

¹ *Revue de Chirurgie*, 1902, vol 140, p. 3506.

ity of the Fallopian tube, it is therefore apparent that tension on the ovario pelvic ligament will tend to produce the prolapse of ovary and tube as contents of the sac. If the hernia is a large one, the body of the uterus may become one of the contents.

In right sided female hernia, the cæcum and appendix may occupy the sac, and for this too there is a developmental explanation. The upper reflection of the common urogenital mesentery is related to the cæcum, while below it is attached to the upper pole of the ovary and the outer end of the Fallopian tube. Part of this common mesentery becomes the ovario pelvic ligament, and if this structure retains its connection with the cæcum it may affect it in the same way as it does the ovary.

DISTINCTIVE POINTS IN THE CLINICAL FEATURES

If the ovary is present in the sac both local and general disturbances are noted. Locally there is hyper sensitiveness and pain, this is more especially the case where the ovary becomes irreducible, as it readily does. Generally the female child may suffer from attacks of vomiting and irritability, which are only to be explained by the sympathetic disturbances associated with the congestion and irritation of the prolapsed ovary. The rarity of intestine as a content makes strangulation in the ordinary sense of the term very rare.

SPECIAL POINTS IN DIAGNOSIS

In female children there are three conditions which resemble inguinal hernia —

- 1 Hydrocele of the canal of Nuck.
- 2 Enlarged inguinal glands.
- 3 Femoral hernia.

1 A hydrocele of the canal of Nuck resembles an irreducible hernia in which the ovary forms the contents, and it may be impossible to differentiate between the two. The hydrocele, however, is completely irreducible, there is absence of tenderness, while it has a sensation of fluctuation on palpation.

2 Enlarged glands may be excluded because of their position and the history with which they are associated.

3 Femoral hernia is excluded because of its relationship to the spine of the pubis, the neck of the femoral sac lies external to and at a lower level than, the spine.

PECULIARITIES OF TREATMENT

Exactly the same principles guide one as have been detailed in the account of male herniæ. The operation is of course distinctive. There is sometimes difficulty in isolating the sac, as the landmark of the cord is absent, and the round ligament may be indefinite. It is therefore advisable to begin by defining the external ring. When

the sac after ligature should be treated with pure carbolic in order to prevent tuberculous infection of the operation wound.

INGUINAL HERNIA IN THE FEMALE

The occurrence of inguinal hernia in the female child is, relatively speaking, infrequent. The explanation of this is apparent. The ovary is an intra-abdominal organ, and the processus vaginalis is therefore not the distinctive structure which it is in the male; in other words, a pre-formed sac does not exist with the same constancy as it does in the male child. The proportional incidence of hernia in males and females is about 20 to 1.

SURGICAL ANATOMY

The canal of Nuck is the analogue of the inguinal canal in the male; it transmits the round ligament of the uterus and a branch of the uterine artery.

The genital gland (ovary), together with its ligaments, descends during the growth of the embryo. It arises in the lumbar region by the side of the vertebral column, but in the last weeks of uterine life it comes to lie in the iliac fossa above the pelvic brim. Immediately before puberty the ovary descends into the true pelvis to assume its final adult position. During the period of its active descent a process of peritoneum, the analogue of the processus vaginalis in the male, descends in a certain proportion of cases along the inguinal canal in company with the round ligament. This process of peritoneum, if unclosed, becomes the pre-formed hernia sac, or, if imperfectly occluded, it may form the hydrocele of the canal of Nuck.

DISTINCTIVE POINTS IN PATHOLOGY

In every instance the sac is of a simple pear shape; it rarely attains any great size. It lies on the ventral surface of the round ligament, so that the fibres of the latter are stretched out on its postero-lateral surface. It possesses coverings derived from the muscular strata through which it passes, but these are incapable of differentiation. The branch of the uterine artery which accompanies the round ligament runs on the posterior surface of the sac, and it is a point of practical importance that, if this vessel is injured at the neck of the sac, the bleeding which ensues may be exceedingly difficult to arrest. The vessel retracts into the extra-peritoneal tissues, and several cases of fatal hæmorrhage have been recorded from the accident.

The ovary is the most common content of the female sac, and for this there is an anatomical reason. If a hernia sac is present, the migration downwards of the peritoneum displaces the outer attachment of the ovario-pelvic ligament. Now, the central attachment of this ligament is to the upper pole of the ovary, and indirectly to the extrem-

The third variety, if uncomplicated by an oblique hernia, is treated by conservative measures. Truss treatment is advised, anti rachitic measures are instituted, efforts are made to develop the abdominal musculature, and the abdominal distention is counteracted by the administration of charcoal.

If an oblique hernia is present in addition, it is wise to advise operation, as the tendency is for the rupture to increase in size.

FEMORAL HERNIA

In contrast to inguinal hernia, the occurrence of the femoral variety is rare. Out of the last 1,000 cases of hernia, seven were examples of the femoral type. The sex incidence, which is so constant in the adult, is maintained in relation to the child, we have never met with an instance of the error in a male child.

ETIOLOGY. We have no doubt that a pre formed sac exists in these cases. We have observed a femoral hernia of considerable size in a baby four months old, and from the anatomical characters of the sac in this case we are convinced of the congenital origin.

THE ANATOMY AND PATHOLOGY of the error is exactly similar to that met with in adults.

The common content of the sac is omentum, and there is the same liability to strangulation as is met with in the adult.

PECULIAR CLINICAL FEATURES. Several observers have drawn attention to the fact that children complain of pain in femoral hernia to a greater extent than they do in the inguinal variety. Proximity of the sac to various superficial nerves probably explains this feature. Sometimes the presence of the hernia in a sensitive child interferes with walking, and the author has seen several cases in which a limp was due to the presence of a femoral hernia.

THE DIAGNOSIS OF FEMORAL HERNIA IN CHILDREN. The absence in the child of an excessive amount of fat and the ease with which parts can be palpated usually makes the diagnosis of femoral hernia easy. It is important to recognize the relationship of the neck of the sac to the spine of the pubis—the neck lies below and to the outer side. This relationship is sufficient to distinguish between the inguinal and femoral varieties. Enlarged glands in the groin of the child may closely simulate femoral hernia, but careful palpation of the swelling will demonstrate that the former is a firm irreducible tumour without any true impulse on coughing or straining.

THE TREATMENT OF FEMORAL HERNIA IN CHILDREN. For two reasons operative treatment is more urgently demanded in femoral hernia than in inguinal. These are the liability to strangulation, and the difficulty which there is in properly adjusting a femoral truss in the child.

the sac has been recognized, the question arises whether it is to be isolated from the round ligament or whether both structures are to be dealt with together. Our practice has been to separate the sac as completely as possible from its coverings and from the round ligament; we believe that by doing so a more efficient radical cure is obtained. When the neck of the sac is defined, care should be taken to secure the vessel to which allusion has already been made. In other respects the operation and after-treatment are similar to that described for male hernia.

DIRECT INGUINAL HERNIA

This condition is so rare that only brief consideration need be given to one or two distinctive facts in regard to it. In children there are three types of hernia to which the qualification of 'direct' may be applied:—

1. That in which there is a pre-formed or congenital sac which passes between the fibres of the conjoined tendon and appears on the surface through the external ring—this type is extremely rare. It is supposed to originate from the fossa which naturally exists between the inferior epigastric umbilical and the obliterated arteries.
2. Cases in which there is a congenital absence of the lower fibres of the conjoined tendon, and, through the weak space which thus exists, a direct inguinal hernia of acquired origin develops. An extroversion of the bladder is usually accompanied by a hernia of this type.
3. In flabby and rachitic children, a direct hernia may occur which closely resembles a similar condition in the adult. There is a bulging forwards through the posterior wall of the inguinal canal, internal to the epigastric vessels. This variety is sometimes combined with a small funicular sac, and in these cases the oblique depression formed by the line of the inferior epigastric vessels appears to divide a single hernia into two divisions.

THE TREATMENT OF DIRECT HERNIA

The first variety calls for no special remarks; the pre-formed sac is ligatured as in the oblique type.

The second variety—that met with in extroversion of the bladder—is a difficult problem on account of the imperfect development of the lower fibres of the conjoined tendon. It may be possible to mobilize the internal oblique sufficiently to stitch it to the upper surface of the inguinal ligament (for the operation which one desires to perform is similar to that of the Bassini operation in the adult), but, if this should prove impossible, a flap is reflected from the anterior surface of the rectus muscle so as to fill the gap.

UMBILICAL HERNIA

Varieties From the clinical standpoint two varieties of umbilical hernia are met with in children —

- (1) The congenital umbilical hernia
- (2) The post natal hernia which develops subsequent to the ligation of the cord at birth

The origin, clinical features and treatment of these varieties are so distinctive that separate consideration must be given to each

The Congenital Umbilical Hernia

When at the birth of the child it is found that a greater or less amount of the abdominal viscera is protruding through the region of



FIG 415 —Congenital Hernia into the Umbilical Cord (New born baby)
The sac contains a quantity of small intestine and a portion of the liver

the umbilicus into the substance of the umbilical cord, the condition is accurately defined as a *congenital umbilical hernia*

THE ORIGIN OF THE HERNIA If the anterior abdominal wall of a seven weeks' embryo is examined, a good appreciation is obtained of the origin of the different types of umbilical hernia. The centre of the lower half of the anterior abdominal wall is occupied by the umbilical cord and its associated structures. In comparison with later life the relative size of the cord to the body wall is very great, for at this period (seven weeks) it occupies rather less than half the space between the supra sternal region and the symphysis pubis. Above the umbilical cord there is a triangular space, the primitive linea alba, bounded below by the umbilical cord, laterally by the recti muscles, above by the lower portion of the pectorals, and by the developing sternum.

Within the umbilical cord there lies the vitello intestinal duct,

If for any reason operation is contra-indicated, the best truss to employ is the cross body De Garmo model.

The Operation

The operator has the choice of approaching the hernia through the thigh or by the inguinal route recently described by Seelig and Tuholski (*Surg. Gynec. and Obst.*, Jan. 1914, p. 55), and by Dajaniar. We have given both of these methods a trial, and we feel that, where children are concerned, the inguinal route has special advantages. Recognizing that the sac is a congenital error and not acquired, ligation and removal of the sac is in itself sufficient guarantee of cure; this is most efficiently done by the inguinal route. Other advantages of the method are that there is little risk of injury to the femoral vein, that the wound is in a more suitable position for subsequent dressing, and that the method brings inguinal and femoral regions into view, and if an inguinal sac is present, it can be corrected without the necessity for a second incision. The method has obvious advantages if strangulation is present.

The Operative Procedure.

The preliminary details are similar to those mentioned for inguinal hernia. An incision similar to that used for inguinal hernia is employed. The inguinal canal is opened by splitting the fibres of the external oblique in the line of the long axis of the external ring. The cord is exposed and retracted upwards. Behind and below the cord and to the inner side of the inferior epigastric artery, the transversalis fascia is in view, and this is torn through by a dissector. Separating the underlying layer of fat, the neck of the hernia comes into view. The lower edge of the inguinal ligament is strongly retracted downwards; care is taken to ascertain whether an aberrant obturator artery is present, and the inferior epigastric vessels are retracted upwards and outwards. The finger is now hooked round the neck of the femoral sac, and with a little tension (for in the child the parts are not adherent) the complete sac of the hernia is dislocated from the thigh into the wound. After ascertaining that the sac is empty, the neck of the hernia is ligatured flush with the peritoneum and the sac is cut away. It is not our practice to close the crural ring in any way; believing in the congenital origin of the sac, we consider that removal is sufficient, but it is important that no dimple be left at the site of the ligatured neck.

If the operator desires to close the crural ring, this is done by inserting several sutures which pass from Cooper's ligament—the tough fascia which covers the horizontal ramus of the pubis—to the edge of the inguinal ligament. The outermost suture should be placed first, and in doing so special care must be taken of the iliac vein.

white band of fibrous tissue. The walls of the sac are often so thin and translucent that an idea can be obtained of the nature of the contents before the sac is opened. Small intestine is a constant content,

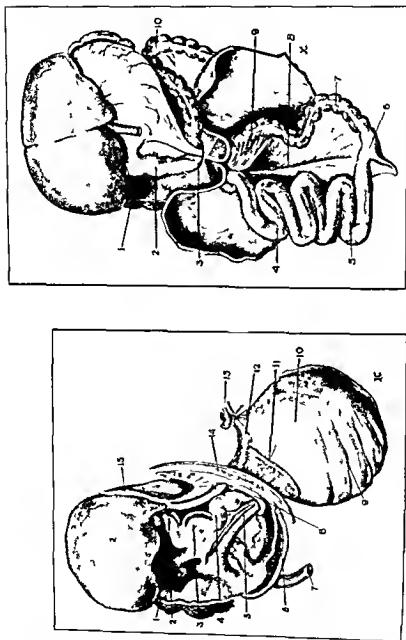


FIG 417—Exomphalos. Specimen obtained from Baby 36 hours old.
 A. Sac unopened, but intra-abdominal portion of viscera exposed in order to show the relationship of the duodenum to the superior mesenteric artery. B. Sac opened, leaving umbilical opening intact. The small intestine occupies the right half of the sac and the large intestine the left. The apex of the midgut loop lies in the lower portion of the sac. (B, permission of the *British Journal of Surgery* and Mr. Doct.)

with sometimes the caecum and appendix. The stomach may be prolapsed, and on one occasion we found a complete lobe of the liver. When small intestine is present the attachment of the vitello intestinal duct must be recognized and divided before reduction of contents is

which connects the yolk sac with the intestine (the ileum). Previous to the sixth week of development a U-shaped loop of intestine derived from the mid-gut is lying in an extra-abdominal position, being situated in a funnel-shaped cavity, *the umbilical cœlom*, within the umbilical end of the cord.

In the light of these developmental facts it is easy to understand that there are at least three ways in which an umbilical hernia may arise:—

- A. The umbilical cœlom may persist and retain within its cavity a portion of intestine, either alone or in conjunction with one or more viscera with which the intestine is related.
- B. The umbilical cœlom may close imperfectly, leaving a small protrusion of peritoneum at the umbilical end of the cord.
- C. There may be an error in closure of the foetal linea alba, the triangular space above the umbilical cord.



FIG. 416 —Hernia into the Umbilical Cord (Exomphalos) (new-born Baby).

The first-mentioned possibility (A) is the cause of congenital umbilical hernia. There is a persistence of the umbilical cœlom, with retention within its cavity of certain of the abdominal viscera, and if this error exists in any marked degree it is accompanied by the third error (C), an imperfect fusion of the supra-umbilical linea alba.

THE PATHOLOGY OF THE CONGENITAL UMBILICAL HERNIA. At the umbilical end of the cord there is a cone-shaped or circular enlargement of varied size, the base of the cone being continuous with the tissues of the abdominal wall. The walls of the cone are composed of thinned-out Wharton's jelly of a blue translucent character, and at the line of junction of the cord and the abdominal wall there is a

In the cases which have come under our own observation, we have found it sufficient after reduction of contents to close the abdominal defect with through and through silkworm gut sutures guarded superficially with rubber to prevent cutting into the thin abdominal wall of the newborn child. It is usually necessary to trim the umbilical edges before the sutures are inserted. After closure, taped plasters are applied over the dressing in order to reduce the tension while the wound is healing.

RESULTS OF THE OPERATION It is surprising how well a newborn child stands what is essentially a severe operation. Our experience has been that if reduction of contents is possible without much manipulation and without amputation of parts, the majority of children recover.

The Post-natal Umbilical Hernia

This variety of umbilical hernia is common, and, if importance is to be judged by the ratio of its occurrence, it comes next in order after inguinal hernia. It is the small saccular protrusion which appears in the region of the umbilicus, and becomes apparent soon after birth.

The Explanation of its Appearance A direct factor exists in so far as there is a weak area through which the saccular protrusion of peritoneum occurs, there are secondary factors which encourage or originate the protrusion.

The direct factor includes two possibilities—either the persistence of a small protrusion of the umbilical coelom or the imperfect closure of the embryonic linea alba immediately above the umbilicus. If the second possibility is the responsible feature it would be more correct to speak of the condition as a ventral hernia, though its relationship to the umbilicus is so close that it is always described as an umbilical hernia. As a matter of fact the deficiency in the linea alba is the most common cause of the post-natal umbilical hernia, only a comparatively small proportion being due to the imperfect closure of the umbilical coelom. In an early case a careful clinical examination will enable one to distinguish between the two possible origins, for a true early direct coelom hernia is situated in the centre of the umbilicus, while that



FIG 419—Congenital double Inguinal Hernia with large congenital Umbilical Hernia (Baby aged 6 months)

possible, and at the same time the operator will observe that the rotation of the intestinal loop has been arrested. A patent urachus is present in many of these cases.

CLINICAL FEATURES. The physical appearances of the hernia are striking. The umbilical cord is greatly increased in girth at its foetal attachment, and it is apparent that within the enlargement there is a considerable prolapse of the child's viscera. Partial reduction of contents is usually possible, but the persistence of the vitello-intestinal duct generally renders complete reduction impossible; sometimes the actual size of the prolapsed viscus (liver) is a sufficient impediment to



FIG 418.—Congenital Hernia into the Umbilical Cord (new-born Baby)

Several coils of small intestine, and a portion of caecum are apparent through the thin-walled sac.

reduction. As a rule, signs of obstruction appear soon after birth, and the more extreme forms of congenital umbilical hernia are rarely compatible with prolonged post-natal existence.

TREATMENT. Operative reduction of the prolapse and closure of the defect is the only satisfactory line of treatment, and this should be attempted as soon as possible after birth. Ordinary taxis is not advisable; it is frequently unsuccessful, and, in any case, operation is necessary in order to close the defect in the abdominal wall.

No definite plan of operation need be laid down, the method must be adapted to the condition which is found. Essentially, however, the procedure will consist in incision of the sac, separation and reduction of the contents, and closure of the abdominal wall.

several circular pieces of broad adhesive strapping. The method is certainly efficient in so far as it prevents contents from entering the sac, while the sac walls are kept in contact.

There are difficulties, however. It is not an easy method in fat children; there is probably a good deal of discomfort, and, unless the strapping is changed frequently, the skin becomes excoriated, and the need for frequent changing robs the method of much of its efficiency.

(b) *The Application of a Pad or Truss* Where the majority of patients are concerned no application is more efficient than a penny, or a piece of lead or aluminum of the same size, covered with lint and secured over the umbilicus with circular turns of adhesive strapping. The application is made while the child is quiet and lying on its back. The contents of the hernia are fully reduced, and the pad is accurately adjusted—the umbilicus should be carefully cleansed and powdered before the pad is applied. The mother is instructed that success depends upon the possibility of keeping the sac empty for a prolonged period of time. If occlusion can be guaranteed for a period of from four to six months there is every prospect of a natural cure.

Several types of spring trusses and rubber belts are sold for the treatment of the condition, but none of them is so efficient as the method of the pad and sticking plaster. A special warning must be given against the use of any truss or pad which is fitted with a small projection intended to fit into the hernia opening. The manufacturers claim that this addition holds the pad in place, but it is obvious that while it may do so, it also certainly prevents closure of the abdominal defect.

2 The Method of Subcutaneous Ligature of the Sac Neck

There is a certain proportion of cases in which for some reason truss treatment is inadvisable, and yet the condition is not sufficiently established to justify a radical operation. For these cases the method of subcutaneous ligature offers an excellent line of treatment.

Indications and Contra indications It is essential that the ring should not be larger than to admit the tip of the index finger, a smaller size is an advantage, but any increase above this scale diminishes the likelihood of a good result. The size of the sac does not matter. It is obvious that the contents of the sac must be completely reducible.

The Technique A piece of solid elastic cord, one sixteenth of an inch in diameter, is used as a ligature (if this material cannot be obtained a piece of stout catgut does equally well). The contents of the sac having been reduced, the fundus of the sac is grasped in forceps and lifted upwards from the abdominal wall. Three small equidistant incisions are now made around the periphery of the sac neck. Each incision is in the long axis of the sac and goes down to the sac wall. With a small blunt dissector the three equidistant incisions are connected by a subcutaneous tunnel which runs as closely as possible to the sac neck. Along the tunnel the elastic cord is threaded, its beginning and its end appearing through the same incision. After ascer-

which is due to the linea alba error appears immediately but distinctly above the umbilicus.

The secondary factors may be grouped as those which increase intra-abdominal pressure or those which lead to an imperfect support of the abdominal wall after birth. The common secondary factors therefore are straining, flatulent distention of the intestine, imperfect support of the abdominal wall by the binder, ligature of the cord at an improper level, and septic infection or sloughing of the cord.

PATHOLOGICAL CHARACTERISTICS. The sac is roughly circular in shape. The fundus is very often adherent to the skin, and the peritoneum may be adherent to the parietes at the neck of the sac—the latter possibility has an important bearing on the question of operative treatment. Omentum or small intestine are the usual contents; they are rarely adherent to the sac wall.

CLINICAL EXAMINATION. The position of the sac should be recognized in case it be mistaken for an epigastric hernia. The size of the ring is tested with the fingers, and the irreducibility or otherwise of the contents is noted. These facts are of importance in guiding the eventual line of treatment.

The clinical examination will include the investigation of any secondary etiological feature which may be found to exist.

THE DIAGNOSIS. It is unlikely that an umbilical hernia will be confused with any other condition. The observer must be careful not to confuse it with the epigastric hernia, which has an entirely different origin. It is possible that umbilical cysts and tumours may be a source of confusion.

TREATMENT

There are three ways in which this variety of hernia may be treated, and under various conditions, each method has special indications. The methods are :—

1. Mechanical occlusion of the hernia sac.
2. Subcutaneous ligature of the sac neck.
3. Radical cure.

1. Mechanical Occlusion of the Sac. By this method we mean the application of a pad or some other contrivance which prevents contents entering the sac, so that a natural closure may be induced. The method is indicated in children below the age of six months, and in those cases in which the ring is so small that it does not admit the tip of the little finger. The method is only applicable if the contents are capable of reduction. Various ways of carrying out this method of treatment are in use.

(a) *Inversion of the Abdominal Wall.* The skin is well powdered with talc or French chalk. The middle line of the abdomen is inverted, and, while it is held in this position by an assistant, it is so secured by

(about $\frac{3}{4}$ inch) It is then transfixed and ligatured, or closed with a catgut suture. The circular ring in the muscular aponeurosis is then converted into a transverse slit by making a small incision at the centre of each lateral margin. Sutures of strong chromic catgut are inserted so as to produce an overlapping of the ring margins (now upper and lower). The operator can choose whether the upper edge overlaps the lower or *vice versa*—the former is the more natural position. The operation is completed by uniting the free edge of the overlapping flap to the underlying abdominal wall.

AFTER TREATMENT The operation calls for considerable care in after treatment. The child is kept from fretting by the administration of chloral or bromide or some other sedative. He is nursed in the supine position for three weeks, and for six or eight weeks after the operation he continues to wear a firm pad and bandage over the position of the hernia.

EPIGASTRIC HERNIA

A small protrusion of extra peritoneal fat in the supra umbilical region and close to the mid-line is spoken of as an *epigastric hernia*. A variety is met with in children which is distinct from the adult type.

PATHOLOGY As far as abdominal herniæ are concerned the condition is unique in so far as no true sac exists. The pathology is a curious one. The hernia is a protrusion of extra peritoneal fat, and the protrusion occurs by the side of a blood vessel, generally one of the perforating branches from the epigastric vessels. If the small pedunculated process of fat is dissected no sac of peritoneum is found to be present.

The exact nature of the origin is obscure, it is difficult to see how the hernia can be explained as an acquired condition—it is more probable that it is a congenital error, the protrusion having occurred coincident with the original formation of the blood vessel which accompanies it.

CLINICAL FEATURES Considering how small the hernia is, and that it contains no sac and therefore no contents, it is surprising to discover that the condition is often accompanied by well marked clinical features. Pain is complained of, the swelling is sensitive and tender to pressure, and after examination of the swelling or sometimes independent of this, there are attacks of nausea and vomiting. The symptoms are out of proportion to the pathological condition which exists and their presence and intensity can only be explained by reflex nerve irritation.

TREATMENT If the swelling is not giving rise to symptoms there is no indication to advise treatment. If pain is present it is aggravated by the presence of the clothes, especially in girls, and when attention has been directed to the swelling by a symptom the various clinical features seem to be exaggerated. Therefore, if the swelling is definitely painful, it is wise to advise operative treatment. Conservative

taining by palpation that the sac is empty, the elastic ligature is tightened, and it is secured in this position by tying a silk ligature around the ends. A simple dry dressing is applied. The elastic cord is kept *in situ* for four or five days, the silk ligature is then cut and the elastic cord removed. The constricting action of the elastic cord has been sufficient to induce a plastic and adhesive change at the neck of the sac, and a cure of the hernia follows.

The method is an exceedingly simple one. We have performed the operation in several hundred cases, and there has been no instance of recurrence.

There are three special points to be observed in connection with the operation :—

- (1) The ring must not be too large.
- (2) The contents must be completely reduced.
- (3) The sac lumen must not be opened when the separation at the neck is being carried out.

We have found it unnecessary for the child to wear any pad or appliance after the operation. A single suture may be inserted in each of the small incisions, but as a rule these fall into place and require no suture.

3. The Radical Cure. *Indications.* This operation entails a complete closure of the opening in the abdominal wall through which the hernia protrudes, and it is indicated under certain conditions. A hernia with a ring which admits the thumb is rarely curable by any other means than a radical cure. Irreducibility or strangulation of contents is an indication for a radical cure.

The operation is not one to be undertaken without a good deal of consideration. It is by no means easy to perform, an imperfect operation is liable to be followed by a recurrence, and the interference with the musculature of the abdominal wall in young children has a special danger—it is apt to be followed by collapse of the lung. Keeping in mind the last possibility, the operation should not be performed upon children below the age of three years.

Technique. The operation is performed in a method very similar to that which is used in adults—the method of sliding upper and lower flaps of the abdominal wall (Mayo's method). A transverse incision is made across the hernial sac and over the abdominal surface for a short distance on either side. The incision on each side of the sac is deepened until the aponeurosis of the abdominal wall is exposed, and, after ascertaining that the sac is empty, or at least that no intestine is present, the sac fundus is opened so that it is in two halves, upper and lower. From the interior of the sac a circular incision is carried round the peritoneum of the sac about $\frac{1}{2}$ inch from the ring, and a cuff of sac is separated so as to leave a tube of peritoneum projecting from the ring. This tube is separated from the edges of the ring, and from the deep surface of the abdominal wall for a short distance around

extremities of the costal and spinal fibres. On the right side such a possibility is not uncommon (the spino costal hiatus), but the presence of the liver is sufficient to occlude any opening. If such a hiatus exists on the left side, however, it forms the opening through which a diaphragmatic hernia passes.

PATHOLOGY The hernia, as met with in children, is practically always congenital, and therefore a sac wall exists, in this respect it is different from the traumatic sacless hernia of adults. The gap in the diaphragm is usually an extensive one, and the common contents of the hernia are stomach, colon, small intestine and spleen.

CLINICAL FEATURES For years there may be an entire absence of symptoms, and then, often with extreme suddenness, a group of the most perplexing symptoms appears—there is dyspnoea with cyanosis, there are signs of cardiac embarrassment, there may be vomiting with a complaint of pain in the lower part of the chest, and signs which one associates with an intestinal obstruction. As suddenly as they appeared the symptoms may vanish, and with their disappearance the child appears to be normal.

The physical examination may show a great variety of features, but there is one which, from the surgical point of view, is pre eminently important. In practically every diaphragmatic hernia the stomach is displaced and the change can be demonstrated by bismuth meal and X ray examination. Practically it is upon the demonstration of this point that a pre operation diagnosis is based.

TREATMENT The symptoms which attract attention to a diaphragmatic hernia are really those of incipient strangulation, and sooner or later in the majority of cases definite strangulation appears. There is then no choice of treatment but operation.

It used to be urged that surgical interference should be limited to dealing with the complications, but our knowledge of chest surgery has now made such advances that, if a diagnosis of diaphragmatic hernia is made, the possibility of strangulation is so likely that an interval operation should be advised which will reduce the hernia and attempt to close the diaphragmatic defect.

The operation is one of great technical difficulty. Access to the defect is obtained through the chest wall.

UNDESCENDED AND MISPLACED TESTIS

It will be recalled that the testis and epididymis originally develop as intra abdominal organs, and in the course of intra uterine life they migrate from the abdomen along the inguinal canal into the scrotum. Under certain conditions, which we shall attempt to explain, an error appears in the process of descent of the testis, and as a consequence there is an interference with its normal migration.

CLASSIFICATION The error may lead to arrest of the descending

treatment by means of circular rings or pads is rarely of value, and the operative procedure is exceedingly simple and efficacious.

The Operation. A small incision is made to one side of the swelling, and a few touches with a dissector separate the small hernia of fat as it projects through the muscular aponeurosis. Coursing by the side of the tumour is the blood-vessel, the significance of which has been already explained. No attempt should be made to separate the one from the other—any such attempt will result in a hæmorrhage which obscures the subsequent proceedings. Both fat and vessel are included in a ligature, and this is tied as close as possible to the abdominal wall. It is unnecessary to open up the aponeurotic tissue, but, as the ligature is passed, the needle which has been used for this purpose should include a bite of the aponeurosis. The skin wound is closed with a single suture.

DIVARICATION OF RECTI MUSCLES

Young children sometimes show a wide separation of the recti muscles above the umbilicus, so that when the child cries or strains a longitudinal bulge appears in the gap between the umbilicus and Xiphisternum. The error is to some extent congenital in so far as the muscles are set abnormally widely apart, but in addition to this there is a stretching and weakness of the interlacing fibrous tissue that bridges the gap which normally exists between the inner edges of the upper halves of the recti. The error is usually met with in children who are or have been the subjects of rickets, and any persistent flatulent distention of the abdomen will exaggerate the deformity.

It calls for no surgical interference—in fact, it demands no treatment beyond that of any coincident condition which may have had an influence on the origin. Parents sometimes insist that something be done, and the application of a small longitudinal pad and bandage will satisfy this demand. It may be definitely asserted that, as age advances, the error becomes spontaneously cured.

CONGENITAL DIAPHRAGMATIC HERNIA

The possibility of diaphragmatic hernia occurring in a child should be borne in mind, because it may explain a group of perplexing symptoms.

THE ORIGIN OF THE HERNIA. The developing diaphragm is built up of a number of different structures of muscular origin, and evidence of this is found in post-natal life in the demarcation which exists between the costal portion, the tendon and the spinal fibres. Each of these has developmentally a different origin, the costal fibres from the abdominal wall, the central tendon from the septum transversum, the spinal fibres from the transversalis muscular sheet of the body wall. It may be that a hiatus persists between the posterior

pletely retained in the abdomen it will be found that the gubernaculum is very imperfect, that it has not descended to any extent along the canal, and no external abdominal ring can be differentiated, if the testis is retained within the inguinal canal, the gubernacular descent has been arrested immediately beyond the external ring, and so on throughout the various degrees of the imperfect descent

The pertinent question arises as to what is the influence which affects the descending gubernaculum. According to certain investigators, the presence of lymphatic tissue is the influence which attracts the spear shaped and actively extending gubernacular tissue, and, if this view is correct, it is natural to assume that a congenital absence or an abnormal distribution of the groin lymphatic tissue is the primary fault

PATHOLOGY

In addition to the error of the gubernaculum attachments, there are other distinctive points in the pathology. Unless the testis is completely retained within the abdomen a hernia sac of the vaginal type is almost constantly present. If the testis has descended to a moderately low level, e.g. if it lies in the neighbourhood of the external ring, the hernia sac is of the superficial or pro parietal variety, the pear shaped sac appearing through the abdominal ring and turning upwards in the subcutaneous tissues upon the external oblique. Both testis and epididymis are smaller than normal, and the more extreme the degree of retention the greater is the atrophy of the organs. If the organs are intra abdominal, it is not uncommon to find that the body of the testis is completely disassociated from the epididymis. Even in less marked degrees of retention, minor degrees of disassociation occur.

The veins and the vas deferens are normal in their distribution frequently there is an abnormal vessel, a branch of the internal iliac which runs distinct from the cord along the line of the inguinal canal its recognition is important when operation is carried out.

The scrotum is imperfectly developed because it has never been opened up by the descending gubernaculum, by the processus vaginalis or by the testis.

CLINICAL FEATURES

The abnormality is said to occur in about 1 in 1,000 male children. Congenital idiocy and mongolism are sometimes associated with it, and any gross error in genito urinary development such as extroversion of the bladder, is almost constantly accompanied by it. The error may occur on one side (monocryptorchid), or on both sides, and in our experience the condition is as frequently double as single. If the condition is unilateral there is probably an increase of functional activity in the healthy testicle and no general body changes may be displayed, the bilateral variety is a much more serious

testicle in any portion of the course: *cryptorchism* or *undescended testis*. There are three common situations in which the retention may occur:—

- (1) The testis may be retained within the abdomen.
- (2) It may remain within the inguinal canal.
- (3) It may lie just beyond the inguinal canal at the opening of the external ring.

On the other hand the testis may descend, but, instead of passing into its normal 'locus' in the scrotum, it is found to occupy an abnormal position such as the perineum or the front of the groin, a *misplaced testis* or *ectopia testis*.

CRYPTORCHISM OR UNDESCENDED TESTIS

THE ORIGIN OF THE DEFORMITIES

A normal descent of the testis is dependent on two associated structures—the plica vascularis and the gubernaculum. The former must be of sufficient length; the latter must be an active tissue with a lower attachment to the front of the symphysis pubis and the base of the scrotum.



FIG. 420 —Imperfect Descent of the Left Testis (Baby 8 months old).

The left half of the scrotum is undeveloped

Cryptorchism or undescended testis may conceivably be due to abnormal shortening of the plica vascularis (the spermatic vessels) or to an error in the development or attachments of the gubernaculum. Practically it would not appear that shortening of the vessels has any real influence, and numerous operative and pathological investigations by the author have led him to support this assertion. Beyond doubt the abnormal-

ity lies in the gubernaculum. During intra-uterine development this structure has a wide lower attachment; it extends through the anterior abdominal wall which it tunnels to form the inguinal canal, it is attached to the front of the symphysis pubis, to the scrotum, and to the groin and front of the thigh. It can be demonstrated that when cryptorchism is present there is a varying degree of abnormality in the gubernacular attachments. If the testis is com-

and atrophy of the organ. The action of the muscles sometimes produces torsion of the cord, with its attendant acute signs. An inguinal testis (situated in the inguinal canal) may undergo a sarcomatous degeneration, and in our experience it does so more commonly than the abdominal testis. Its liability to this change is probably related to the irritation from the contracting abdominal muscles.

If the testis lies beyond the canal two complications are likely to occur—the testis may be bruised against the pubic bone, and the proparietal hernia, if such is present, may undergo strangulation. Strangulation is always a menace in the case of a proparietal hernia, because of the acute angular arrangement of the sac, and therefore of its contents —

TREATMENT

When a child afflicted with undescended testis is brought to the surgeon's notice the advice which he gives is affected by certain considerations —

- (1) *Age* No operation except under the conditions stated below (3) should be advised until the child is four years old. This age is fixed as the period of election, though it need not be strictly adhered to, the reasons for its choice are that up to the age of four, natural descent tends to continue, that if the operation is done in the first two years of life the testis may atrophy, and that soon after the age of four the child begins to go to school, or to associate with other children.
- (2) *Position of the Testis* If it is recognized that the testis is abdominal, no operation should be carried out. If the testis lies outside the inguinal canal, operation may be delayed later than would be otherwise considered advisable, because from this position further descent may be expected to occur. A testis which lies within the inguinal canal should be operated on at the age of election (four years).
- (3) *Evidence of Complication* The occurrence of any complication should be accepted as an indication for operation irrespective of age—this is especially true in application to sub-acute orchitis and torsion of the cord, as these so commonly result in atrophy and loss of function.

There are other less important points which affect the time at which operation should be performed—a bilateral error is operated on earlier than a unilateral, if there is stunting of the growth and evidence of diminished testicular secretion, early operation is indicated.

Is there a Conservative Treatment?

Sooner or later the question is put to the surgeon—can anything be done for the condition apart from operative treatment? and, while the surgeon should unhesitatingly urge operation of the condition as soon as indications are favourable, there are three conservative points which he has to bear in mind

matter—growth may be interfered with, the nervous system is highly strung and unstable, and there may be evidences of a reversion to a feminine type.

Locally the clinical features will vary according to the degree of retention. In the most extreme degree, the testis is not palpable, the external inguinal ring is closed, and no hernia is apparent, the scrotum on the affected side being shrunk and contracted. In the less extreme degrees the testis is palpable, a hernia which may be of the proparietal type is often present.



FIG. 421.—Undescended Testis (left side) (Boy $7\frac{1}{2}$ years old).

region immediately below the external ring is carefully palpated. If the testis is descended the cord is picked up in this position, and by following it the testis is found.

A hydrocele of the cord and a small irreducible hernia are sometimes confused with an undescended testis, but careful routine examination of the parts is sufficient to prevent confusion.

COMPLICATIONS OF UNDESCENDED TESTIS

If the testis is retained within the abdomen it is said to be liable to undergo a sarcomatous degeneration. Instances of this occurrence are rare.

It is when the testis lies within the inguinal canal that complications are most likely to ensue. The repeated contractions of the abdominal muscles may lead to a chronic traumatic orchitis with resulting fibrosis

DIAGNOSIS

Under this head one point of special importance must be alluded to. Certain children show such a strong cremasteric reflex that when the contraction is in force the testis seems to leave the scrotum and disappear into the canal. As a matter of fact it does not enter the canal, but it lies under cover of the loose fatty tissue which covers the front of the pubis. This unusually developed cremasteric reflex is often associated with a neighbouring focus of irritation, such as phimosis or balanitis. If it should happen that the physician examines the child while the reflex is active, it is very easy to fall into error and to assume that the child is the subject of undescended testis. The mistake, which is a very common one, is avoided if the

efficient replacement of the testis. It is essential to retain the vas and its artery, and of course the veins are not divided unless the demand is urgent.

One thing certainly is clear—it is never necessary to remove the testis, as was previously advised. The vas is capable of a great degree of extension, and, if the testis is recoverable, it can certainly be placed in the scrotum.

Having secured the liberation of the testis, the scrotum is hollowed out with the finger in order to receive it, and the separation should be made as complete as possible. The testis having been placed in the scrotum, the question arises as to whether means are to be used to retain it in position. We believe that, if the testis is efficiently liberated, no means of fixation are necessary, but, if any duibety exists, a catgut stitch is placed which secures the testis to the connective tissue in the base of the scrotum. The stitch should not penetrate the skin of the scrotum, in case of infection entering, above it should pass through the tissue between testis and epididymis.

Other methods of anchoring the testis have been advocated, such as division of the scrotal septum and placement of the testis in the scrotal pouch of the opposite side, securing it there by a stitch which passes through the scrotum and is attached to the skin of the thigh of the opposite side. We have never found it necessary to employ these more intricate methods, and we believe that the essential of success is efficient primary liberation of the testis.

The wound is closed as in an ordinary hernia operation.

AFTER TREATMENT There are no points of special importance in regard to after treatment. The methods of nursing are similar to those used for hernia. If there are evidences of a diminution of the internal secretion of the testis, glandular therapy should be instituted.

Results of the Operation From an æsthetic point of view the results are invariably good. For some weeks after the operation there may be a good deal of swelling of the testis, but this subsides and conditions return to normal.

The results in regard to sexual recovery are less satisfactory, but they have been improved by the institution of operation at the most suitable period.

MISPLACED TESTIS—ECTOPIA TESTIS

Many of the remarks which have been made in regard to undescended testis are appropriate to this condition. The testis descends, but, instead of passing into the scrotum, it finds a resting place in some adjacent part of the subcutaneous tissue, such as the perineum or the groin.

It is observed that the error depends upon an abnormal lower attachment of the gubernaculum. Wherever the main lower attach

The first is the exhibition of testicular extract. It is said that if employed in the early years of life it improves the chances of the testis descending. We have no proof of this assertion. The method should only be used if there are evidences of diminished testicular secretion such as stunting of body growth.

The second point is the wearing of a truss if a hernia is present. The variety of truss to be used must be carefully chosen in case pressure is exerted upon the testis—a Macready truss is the most suitable.

The last is the question of aiding the testicular descent by massage and traction on the testis. Parents often inquire about this point. It is unlikely that any benefit follows its use, and it may lead to the adoption of vicious sexual habits: its use is therefore to be deprecated.

Operative Treatment

The preliminary treatment is similar to that recommended in connection with hernia operations. An oblique incision is made over the position of the inguinal canal on the affected side, the incision being slightly longer than that used for inguinal hernia. The position of the external abdominal ring is defined and the space is opened up. Unless the testicle is lying at a high level, a collection of loose connective tissue mixed with muscular tissue is apparent—the end of the imperfect gubernaculum. Traction upon this will bring the testicle into view. It is now necessary to expose the length of the cord as completely as possible, and, to do so, the anterior wall (the external oblique) is divided in the line of the cord. The testis, with the cord and its associated structures, are now freed from the bed of the inguinal canal and lifted upwards from the wound. It will be found on applying traction to the testicle that the structures which prevent the testis from being brought to a sufficiently low level are the coverings of the cord, the hernia sac, and the veins. The first and second of these are invariably dealt with, the third only occasionally requires to be interfered with. As in the method described for hernia, the shortened cord is stretched out in such a way that the veins and the vas deferens are on the superficial aspect of the cord; with a sharp knife the coverings are divided so as to free the veins and the vas—these are separated and pulled to one side. The veins and the vas are separated upwards to the level of the internal abdominal ring, and at this height the hernia sac is transfixed and tied with catgut. By gentle traction on the testicle it may now be found possible to bring it down to such a level that it can be placed in the scrotum without further division. If, however, there is still difficulty, it may be assumed that shortening of the veins is responsible.

At one time it was said to be unwise to divide the veins, as the procedure invariably resulted in necrosis of the testicle, but we now know that the risk of this occurrence is small, and therefore we have no hesitation in dividing the veins if by so doing we can ensure

CHAPTER XXXIII

SURGERY OF THE ABDOMEN

THE DEVELOPMENT OF THE GASTRO INTESTINAL TRACT

A certain number of surgical conditions affecting the hollow viscera of the abdomen owe their origin and distinctive pathology to developmental errors, it is therefore necessary to review briefly the process by which the gastro intestinal tract is developed

The original Segments The future alimentary canal is derived from the entodermic vesicle of the zygote, and at a very early period this structure is subdivided into two by an intervening constriction. Around one portion of the vesicle the embryo continues to

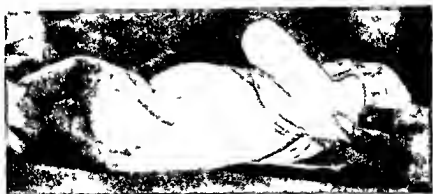


FIG 424 —Fatty Tumour of lateral Abdominal Wall (Baby 5 months old)

develop, so that the included space may be described as the *intra embryonic portion*—the future alimentary canal and its appendages. The *extra embryonic portion* remains recognizable for some time as the yolk sac while the constriction which originally produced the subdivision is the *vitello intestinal duct*.

As the embryo continues to develop, and head and tail folds of its constitution are recognizable, it is possible to subdivide the original *intra embryonic portion* of the entodermic vesicle into *foregut*, *midgut*, and *hindgut*.

The *foregut* is that portion which the embryologist recognizes as delimited by the head fold. In later life it is outlined by the anatomist as the part of the digestive tract which extends from the mouth to the middle of the second part of the *duodenum* (*duodenal papilla*). Its



FIG. 422.—Ectopia testis (Baby 1½ years).

An example of a testis which has passed into the lower portion of the groin. The left half of the scrotum is empty.

misplacement is usually present at birth.

TREATMENT. Every one is agreed that a misplaced testis must be operated on. The abnormal position which it occupies is generally one of insufficient protection, it is constantly liable to injury, and it tends readily to undergo torsion.

The operation consists in removal of the testis from its abnormal position and replacement of it within the scrotum. As a rule the cord is of sufficient length to permit of replacement without division of structures; if a hernia is present, a radical cure is done. The incision lies over the external ring. The cord is picked up as it leaves the ring, and the misplaced testicle is easily separated from its false position. The hernia having been dealt with, the scrotum is opened out and the testis placed within it.

ment of the gubernaculum is directed, the testis follows, and therefore, if the gubernaculum passes into the perineum instead of entering the scrotum, the result will be a perineal misplacement of the testis.

The pathology is very similar to that of the undescended testis—a hernia sac, vaginal in type, accompanies the testis, the testis and epididymis may show atrophy, and sometimes there is absolute dissociation between them. The



FIG. 423.—Ectopia testis (Boy 3 years).

An example of a perineal testis, the left half of the scrotum is empty.

wards, secured at its extremities to the duodeno colic isthmus, and supported throughout its length by the common dorsal mesentery. Within the mesentery, the superior mesenteric artery runs from the dorsal aorta to the summit of the loop, and the point of its junction with the gut is the situation of the attachment of the vitello intestinal duct, for originally the artery is the right omphalo mesenteric artery. Until the end of the third week, the midgut communicates with the yolk sac through the vitello intestinal duct, but after this date the communication ought to close. So great is the rapidity of growth of the midgut, and so much intra abdominal space is occupied by the development of the liver, that the accommodation of the intestine within the abdomen becomes impossible, and therefore it is extruded as a temporary hernia into the root of the umbilical cord about the end of the fourth week of development. The presence of the artery (superior mesenteric) passing towards the summit of the loop conveniently divides the loop into two segments: an *anterior or pre arterial* and a *posterior or post arterial*, and this terminology is necessary for further descriptive purposes.

During the fifth week the midgut is therefore in the position of a partly herniated loop of bowel occupying the sagittal plane, with a diverticulum apparent on its post-arterial segment, which later will form the cæco appendix region. After the fifth week the loop undergoes various changes of rotation, and these changes are of practical importance because of the clinical conditions which may arise from errors in the evolution.

There are three stages of rotation —

Stage A During the period between the fifth and tenth weeks while the loop is herniated.

Stage B During the tenth and eleventh weeks, while reduction of the loop is proceeding, and

Stage C During the period from the eleventh week until birth or even later.

Stage A, the First Stage of Rotation The growth of the right lobe of the liver and the displacement which it exerts upon the left umbilical vein result in pressure being brought to bear upon the pre arterial segments of the midgut loop caudally (i.e. downwards and to the right, with the secondary result that the post-arterial segment is displaced in the reverse direction, being displaced in a cephalic direction (upwards) and to the left. An intertwining S shaped arrangement results, the pre arterial segment forming the right half, the post arterial segment the left half. When this point is reached the first stage of rotation is completed but a disproportionately greater growth of the pre arterial segment and of the cæcal bud with its adjacent colon begins to shape the gut upon its future lines (Fig 425, Nos 1, 2 and 3).

Stage B The second stage of rotation is coincident with the return of the midgut loop into the abdominal cavity. It is supposed

distribution is based upon a vascular foundation, because it is mainly supplied through the cœliac axis, and the physiologist distinguishes it as the region of digestion.

The *hindgut* is described by the embryologist as delimited by the tail fold; to the anatomist it completes the formation of the large intestine from the left half of the transverse colon to the junction of anal canal and rectum, its future blood supply being represented by the inferior mesenteric; it is indicated to the physiologist by its function of excretion.

The *midgut* is the intervening portion between foregut and hindgut; it is the visceral distribution of the superior mesenteric vessel, and anatomically it is represented by the small intestine beyond the level of the duodenal papilla and the large intestine up to the left half of the transverse colon; functionally, it is the area of intestinal absorption.

As early as the third week, the embryonic gut is attached in the central axis of the body by a common dorsal mesentery and by a ventral mesentery.

Further Changes in the different Segments of the Gut.
The Foregut. Relative degrees of enlargement produce the arrangement of the pharynx and œsophagus. About the fourth week a bulging of the foregut into the dorsal mesentery indicates the future greater curvature of the stomach, and the unequal growth of this organ decides its shape and position. The position of the stomach results in a deviation of the duodenum to the right. Into the mesentery of the latter the dorsal pancreatic rudiment grows, and it is the influence of the pancreas which is responsible for the fixation and shape of the duodenum. The lower end of the foregut at the level of the biliary papilla is continued into the upper end of the loop of the midgut.

The Hindgut. The sequence is best understood if the development of the hindgut is now followed. At first it occupies the middle line of the abdomen through the attachment of its dorsal mesentery to the posterior abdominal wall. In this mesentery a thickening becomes apparent (the *colic band*), which connects the upper end of the hindgut to the posterior abdominal wall in the neighbourhood of the origin of the superior mesenteric artery. The effect of the 'suspensory' action of the band is to produce a bend at the junction of midgut and hindgut (the *colic angle*). Actually the duodenum and the colic angle are close together, and, as the embryo develops, this approximation is relatively increased, so much so that the embryologist speaks of the approximation as an isthmus, the *duodeno-colic isthmus*. It is to the two points of the isthmus that the upper and the lower end of the midgut are attached, so that it is suspended as a loop between two fixed points of attachment.

The Midgut. The midgut is the portion of the alimentary tract which shows the most complex developmental arrangements, and therefore it is in this distribution that anomalies of development are most frequently met with. The midgut exists as a loop, convex for-

the return of the gut is that the duodenum crosses behind the superior mesenteric vessels near the origin of the latter, the colon crosses the same point anteriorly, the descending colon has been forced back into the left loin, and the cæcum and ascending colon are lying in the right loin. This completes the second stage of rotation (Fig. 423, Nos. 3 and 4).

Stage C This stage is chiefly related to the fixation of certain of the viscera to the posterior abdominal wall by the fusion of their mesenteries with the posterior parietal peritoneum. It is in this way that the lower portion of the duodenum is fixed and the duodeno-jejunal angle formed. Similarly the cæcum and the ascending colon with the related mesentery are folded towards the right, and under normal conditions should become fixed to the posterior abdominal wall by obliteration of their mesentery—an error of this stage is common in the form of ‘cæcum mobile’. On the left side the descending colon should become fixed, and the mesentery of the intestine should acquire a wide secondary attachment, so that the gut is no longer dependent from a narrow pedicle, but from a wide and stable attachment.

CONGENITAL ERRORS OF THE GASTRO-INTESTINAL TRACT

It is convenient to group the various errors in terms of their origin according as they arise from foregut, midgut, or hindgut.

CLASSIFICATION On this plan the following classification includes the more important anomalies —

<i>Congenital errors arising from foregut</i>	{ Congenital narrowing of the œsophagus		
	{ Congenital pouches of œsophagus		
	{ Congenital absence of œsophagus		
<i>Congenital errors arising from midgut</i>	{ Congenital atresia		
	{ Congenital diverticula or fistula		
	{ Errors of rotation (Congenital Volvulus)	1st stage	Extroversion of cloaca
		2nd stage	{ Non rotation of mid gut loop
			{ Mal rotation of mid gut loop
<i>Congenital errors arising from behind gut</i>	{	3rd stage	Local displacements
<i>Congenital errors arising from behind gut</i>	{ Congenital atresia		
	{ Local displacements		

The question of these various congenital errors is a vast one with a very extensive literature of its own, and in a work of this description it is only possible to touch upon the more practical aspects of the problem.

Foregut Errors

Congenital Narrowing of Œsophagus About the third week of development the human œsophagus is merely an annular constrict

that the pre-arterial segment is the first to return. It does so on the right of the superior mesenteric artery, and, in order to gain the left and hitherto unoccupied side of the abdomen, it passes behind the mesenteric vessel. In this way the proximal bowel is returned into

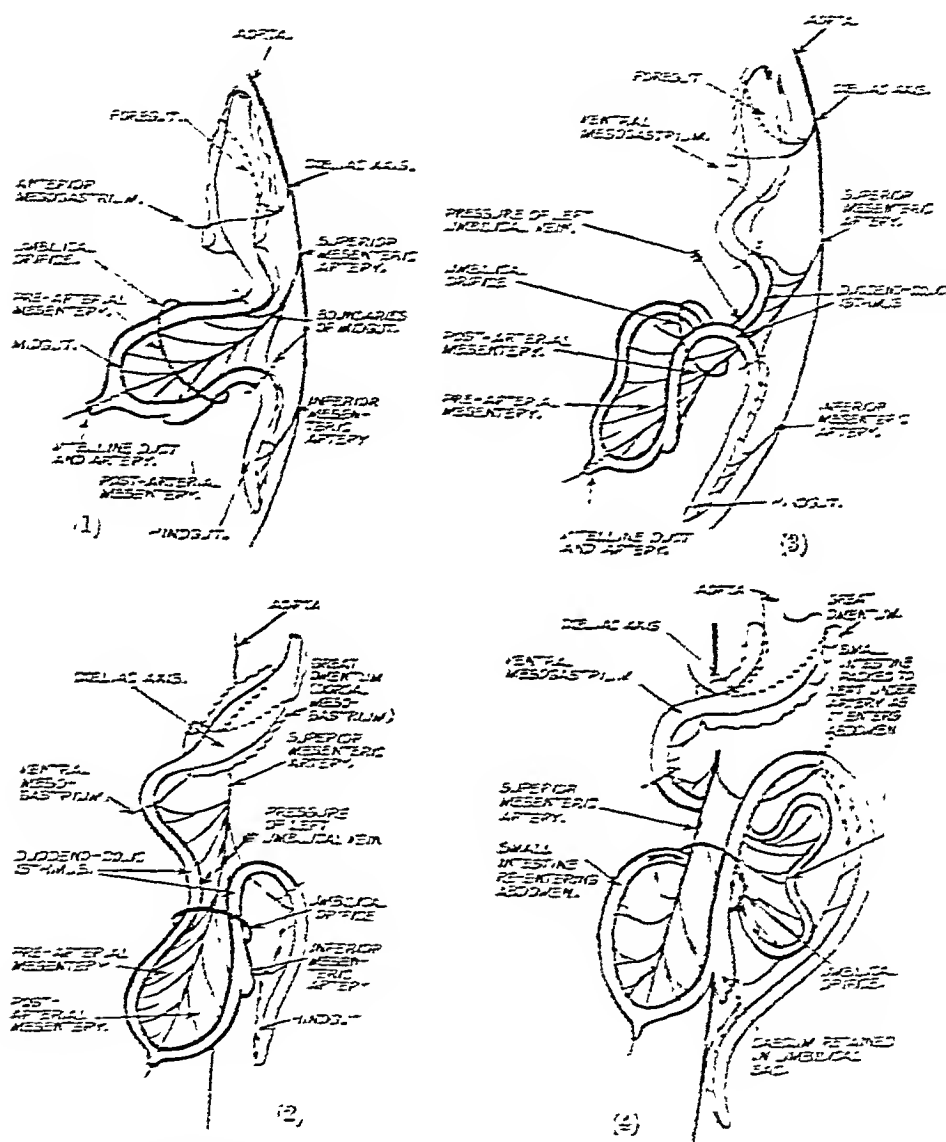


FIG. 425.—A series of Figures illustrating the various stages of rotation of the Intestinal Loop. (By permission of Mr. Norman Dott.)

place before the distal portion, and, as the gut collects, it displaces the hindgut before it into the relative positions of the splenic flexure and the descending colon. The last portion of the ileum to return carries the mesenteric vessel with it, and its return is followed by that of the caecum and the adjacent colon. It is now apparent that the effect of

the communicating type owing to the regurgitation of food into the trachea, and it is inadvisable in the non communicating type because it is impossible to restore the continuity of the œsophagus by any method at present known to surgery. It has been suggested that the objection stated in relation to the communicating type may be overcome by ligaturing the cardiac end of the stomach but this has the effect of merely postponing the inevitably fatal termination. The only treatment available is to relieve the intense thirst from which the baby suffers by administering rectal and subcutaneous saline infusions.

Midgut Errors

Congenital Stenosis At one or other extremity of the midgut, congenital narrowing or complete obliteration of the bowel may occur. The upper extremity is more commonly affected, and the stenosis therefore occurs at the second part of the duodenum in the region of the duodenal papilla. Obstruction at the lower end of the midgut, as represented by the region of the splenic flexure is an event of great rarity.

Wherever the obstruction occurs there is enormous distention of the portion of bowel above the obliteration, and well marked peristalsis may be observed. In the duodenal obstruction, the distention affects the stomach and the first part of the duodenum, and, owing to the constricting effect of the pylorus, it looks at first sight as though the condition was one of hour glass stomach. Vomiting, gastric dilatation and some degree of visible peristalsis are the clinical evidences, and therefore it is not surprising that the condition is sometimes mistaken for congenital stenosis of the pylorus.

The colic type of atresia gives rise to extreme distention of the entire small intestine, no meconium is passed owing to the low

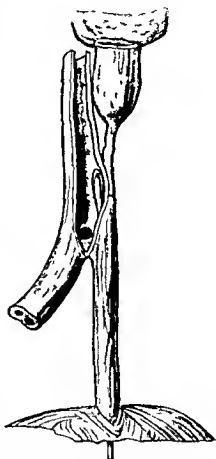


FIG. 426.—Congenital Obliteration of the Esophagus (specimen from Child 8 days old)

The upper portion of the œsophagus is dilated; thereafter the viscus is represented by a cord like structure for a distance of about $\frac{1}{2}$ of an inch. Below this point the œsophagus is normal in size but it communicates at its upper end with the trachea through a fistulous opening.

tion between the pharynx and the stomach. With the formation of the neck the communication elongates and enlarges to form the gullet, but it occasionally happens that the development is irregular, and that a stenosis exists at a point in the length of the œsophageal tube. The situation of the narrowing is usually at the lower end of the œsophagus. When the site is examined no evidence of scar tissue is apparent, all the coats of the gullet are represented, and the lesion is apparently one of local arrest of development.

THE CLINICAL HISTORY is characteristic. Regurgitation of food may exist from birth; sometimes the trouble first becomes apparent when the child is weaned and solid food is an article of diet. A quantity of mucus is mixed with the vomited matter, while there is an absence of gastric contents. When a bougie is passed its progress is arrested at the point of narrowing, and an X-ray examination with an opaque meal may show the exact locality of the lesion. If a certain amount of fluid passes into the stomach the child may exist for years in a condition of gradually increasing emaciation.

THE TREATMENT will consist in an attempt at gradual dilatation of the narrow portion. If the child is in a very weak condition, it may be necessary to carry out a temporary gastrostomy, and in this event it may be possible to secure a retrograde dilatation more easily than by the oral route.

Congenital Pouches. There are a number of cases recorded in which there have been congenital diverticula communicating with the œsophagus. So far as the clinical features are concerned, these do not differ from the corresponding acquired condition in adults. The most common situation of these errors is at the junction of the pharynx and the œsophagus.

Partial Obliteration of the Œsophagus. There is a rare type of deformity in which a portion of the œsophagus is either completely absent or is represented by a fibrous cord.

THE CLINICAL HISTORY is that from birth the child has been unable to take the breast. As soon as a few mouthfuls of milk are swallowed they are brought up again, and it is noticed that violent fits of dyspnœa accompany the vomiting. There is profuse salivation, because the only way of escape for the fluid is through the mouth.

PATHOLOGY. A study of the pathology explains the clinical features. There are two types of the deformity; in one a portion of the œsophagus is represented by a fibrous cord, but there is no communication between the œsophagus and the air passages; in the other (and more common type) the lower or gastric portion of the œsophagus opens into the trachea at its bifurcation, while the upper pharyngeal portion ends blindly in a somewhat dilated pouch with hypertrophied walls. In certain exceptional cases both the upper and the lower portion of the œsophagus communicate with the trachea.

There is no operative treatment which is of avail; a gastrostomy would be the only available procedure, but it is unsuitable for

jection producing no symptoms. The projection always springs from the free border of the gut, and diverticula found in other situations are not derived from the vitello intestinal duct. Its position is on an average about 20 inches from the ileo caecal valve, and the structure of the wall of the diverticulum is identical with that of the lower end of the ileum. The opening into the ileum is sometimes valved, but as a rule it is the full width of the attachment.

The following list includes the more common varieties of the error —

- (1) A Meckel's diverticulum exists which opens on the surface at the umbilicus, and there establishes an umbilical fistula
- (2) The Meckel's diverticulum is attached to the umbilicus, but no communication with the surface exists
- (3) The diverticulum has lost its attachment to the umbilicus and therefore hangs from the ileum as a blind point
- (4) The diverticulum acquires a new attachment to its distal extremity
- (5) The diverticulum may disappear, but the vitello intestinal vessels persist as a fibrous cord partly canalized

The various umbilical conditions depending on the Meckel's diverticulum are described in relation to diseases of the umbilicus.

The practical importance of a diverticulum which hangs loose within the abdominal cavity is that it may undergo an inflammatory infection, a diverticulitis, which it is almost impossible to distinguish clinically from acute appendicitis. We have lately had two cases of this nature, and in regard to this condition there is this point of practical importance, that, as the wall of the diverticulum is considerably thinner than that of the appendix, there is a greater liability for perforation to follow infection.

A Meckel's diverticulum which is attached at both extremities and a persistent vitelline artery are frequent causes of acute intestinal obstruction, because of the bridge like structure which they produce. A persistent vitelline artery has a further danger to which we have elsewhere drawn attention—its visceral attachment may be to one of the branches of the superior mesenteric artery as the latter passes in the ileo caecal mesentery, and we have recorded a case¹ in which traction upon the vestigial vessel produced a rupture of the mesenteric vessel, with a resulting fatal hæmorrhage.



FIG. 428.—Meckel's Diverticulum

¹ *Brit Journ of Surg* Vol VIII p 478

level of the obstruction, but some days may elapse after birth before vomiting occurs.

Operation offers the only possible treatment; vomiting and abdominal distention indicate a laparotomy, and when the abdomen is opened the situation of the obstruction is revealed. Some type of short-circuiting operation is then demanded; in the case of a duodenal obstruction a gastro-enterostomy or a duodeno-jejunostomy will be done, while in the case of the colic obstruction an ileo-

colostomy offers the best prospects of success. In any event the prospect of recovery is exceedingly small.

Apart from errors which are definitely at the termination of the midgut, congenital obliteration of the small intestine may occur in many situations, and it may be single or multiple. The cause of such errors remains a matter of surmise. Complete absence of a segment of bowel or complete obliteration at one point are very rare conditions—much more common is it to find that, while the bowel lumen exists, it has failed to enlarge at one point. It is believed that this error is really a functional one, depending, possibly, upon an irregularity in the distribution of the nerve supply.

Congenital Diverticula or Fistula. If a remnant of the vitello-intestinal duct persists, a congenital (Meckel's) diverticulum will exist in connection with the lower end of the ileum, and the persistence of this stricture may give rise to a variety of surgical conditions. A



FIG 427 —Umbilical Fistula, communicating with the interior of the small intestine through a patent Meckel's diverticulum

Meckel's diverticulum is the neck of the yolk sac persisting into post-natal life, and, accompanying it, there is often a remnant of the vitelline artery, running in a mesentery which is attached to the diverticulum. All trace of the yolk sac should disappear during the sixth or seventh week of foetal life, and the various evidences of its persistence are matters of considerable surgical importance, because, whatever may be the nature of the remnant which persists, the tendency is for it to pass across the abdomen from the umbilicus to the lower loop of the ileum, and the risk of any such bridge is that obstruction may develop. A Meckel's diverticulum is found in 2 per cent. of all human beings, and in the majority of cases it exists as a fine thimble-like pro-

this does not ensue, the result will be that the whole midgut loop, small intestine and the proximal half of the colon remain suspended by a narrow pedicle (the duodeno coele isthmus). Such a state of affairs is precarious, because of the liability to volvulus which follows the narrow extent of the mesenteric pedicle.

(2) *There is reversed rotation of the midgut loop* It may happen that rotation takes place in a clockwise direction, generally through an extent of about 90° . The result is that the transverse colon passes behind the mesenteric artery while the duodenum crosses in front, the intestine otherwise occupies its normal position, except that the anterior and posterior surfaces are reversed. The practical importance of this variety of error is in relation to the transverse colon, for its erroneous position renders it liable to undergo obstructive changes.

(3) *There is mal rotation of the midgut loop* In this group, various irregularities of the normal rotation are included. It may be that the small intestine passes in front of the vessels to lie on the right side, and by doing so prevents the cæcum from reaching the right loin, with the result that it is retained in the pyloric region, with the duodenum and the last portion of the ileum in close proximity to each other. On the other hand, the small intestine may remain entirely on the right side of the artery, where it again prevents the cæcum and ascending colon from reaching the right iliac region, so that the cæcum and ascending colon retain a long primitive mesentery.

The practical importance of this variety of error is that the narrow mesenteric attachment of the midgut loop renders it peculiarly liable to undergo a condition of volvulus with a resulting high small intestine obstruction.

It will be seen that *non rotation* and *mal rotation* are the errors which are most likely to undergo a volvulus change, and therefore they are the varieties of importance in the surgery of the child. They are to be considered as among the possible causes of an acute intestinal obstruction developing in a baby a few days after birth.

Their treatment is difficult. In many of the recorded cases a gastro jejunostomy has been attempted with indifferent success. It has been suggested that it is possible to replace the bowel in its correct position, undoing the rotation error and securing it in its proper position against the posterior abdominal wall by several sutures. Success has attended this manoeuvre in one or two cases.

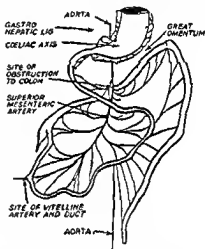


FIG 430 —An example of reversed rotation of the Midgut Loop (By permission of Mr Norman Dott)

Errors of Rotation (*Congenital volvulus*). It is convenient to describe the errors considered under this heading in three groups according to the different stages of rotation which may be affected.

Errors of First Stage.

In the rare condition known as *extroversion of the cloaca* the first stage of rotation is interfered with. In addition to the interference with the development of the midgut the hindgut is either imperfect or misplaced. The error is scarcely compatible with post-natal life, and therefore it is not a matter of surgical importance.

Errors of the Second Stage.

The second stage of midgut rotation is determined by the relative order in which herniated abdominal viscera return into the abdominal cavity. This is the most essential and the most complicated of the various stages, and errors of it are occasionally met with. According to the description given by Dott three

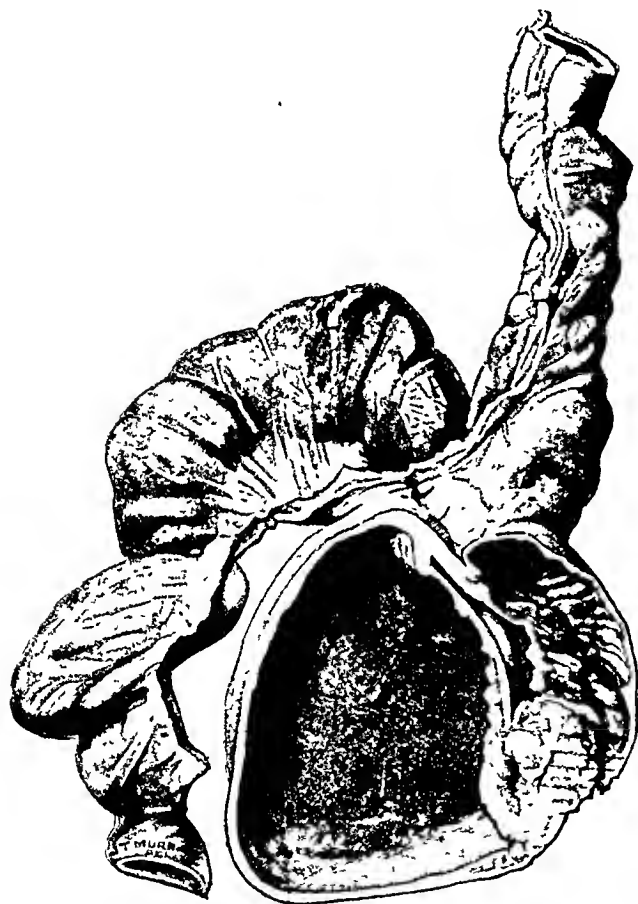


FIG. 429 — Congenital Mesenteric Cyst.

Cyst of congenital origin arising in relation to the mesentery of the small intestine. The cyst cavity communicated with the interior of the bowel and an altered type of intestinal epithelium lined its interior. The cyst gave rise to acute intestinal obstruction.

varieties of error have been noted —

(1) *There is non-rotation of the midgut loop.* The essential features are that the small intestine lies chiefly to the right of the midline, the cæcum lies in the left iliac fossa or in the pelvis, and it is reversed, so that the ileum enters it from the right side, the ascending colon passes upwards and to the left, and there is a narrow and short loop of transverse colon. In such abnormal situations fixation of the viscera may occur by the development of adventitious adhesions; if

inflammation has extended to the peritoneum from an extra peritoneal site, such as the lung, pleura, or joint. The primary type (sometimes called the idiopathic type) is the more important because it is an original and distinctive disease of intense symptoms and high mortality.

From a clinical basis the primary type may show three different varieties—*fulminating*, *acute*, and *chronic*, according to the intensity of the symptoms. Therefore a classification of the disease may be arranged as follows —

<i>Pneumococcal peritonitis</i>	{	Primary {	Fulminating
			Acute
			Chronic
	{	Secondary	

Primary or Idiopathic Pneumococcal Peritonitis

The main surgical interest centres round this type of the disease

ETIOLOGY

There are three factors of great importance in relation to the etiology —

- (1) The manifestations of the disease are confined to female children
- (2) There is an age period which extends from two years to ten years with a point of maximum occurrence corresponding to the fifth year of life
- (3) The disease is practically confined to the poorer classes of society, and especially to those who reside in the crowded dwellings of our large cities

These three factors are linked up with the original and connecting one, that *the disease gains admission through the Fallopian tubes into the pelvic peritoneum*. It is this fact which explains the sex distribution, which tallies with the age period, because it is about the fifth year that the patency of the vagina and the characteristics of the vaginal secretion most strongly favour the infection, and which conforms to the social distribution of the disease, because the over crowding and the imperfect hygiene are powerful predisposing factors in its development.

It is but right to say that there are some who deny that the disease is the result of a direct infection through the genital tract, they claim that there is a pre existing pneumococcal infection of the blood stream—a pneumococcal septicæmia, and that the peritonitis is but a local manifestation of a general condition. In other words, they deny the existence of a primary variety of the disease, and they classify all types as secondary in character. Recent work has been directed towards investigating the relative truth of the opposing views, and the result has been to confirm the explanation of a direct infection through the genital tract.

Errors of the Third Stage.

The third stage of rotation is really one in which the various viscera find their ultimate position and become fixed to the posterior abdominal wall by adhesive processes. Errors of non-fixation or of too early fixation are responsible for a number of abnormalities, many of which are the foundation of pathological changes. Early fixation of the cæcum or failure in elongation of the colon results in an undescended cæcum. Deficient fixation or abnormal elongation of the colon is the explanation of the low pelvic type of cæcum. Imperfect fixation of the mesentery of the post-arterial loop (cæcum) accounts for the various degrees of mobile cæcum.

Many of these changes are of importance in relation to adults because of their bearing upon visceroptosis. Certain of them, however, have an influence upon the abdominal emergencies of childhood. Intussusception, for example, is closely associated with a mobile cæcum, deficient fixation of the colon is a predisposing cause of ileo-cæcal volvulus, while an undescended cæcum with the unusually high appendix may lead to many difficulties in diagnosis.

Hindgut Errors

The hindgut is largely free from congenital errors. Stenosis may occur at either extremity of the segment, and this error is more common at the lower than at the upper extremity; it is discussed in connection with errors of the rectum and anus.

It sometimes happens that the attachment of the hindgut is erroneous, and the bowel occupies the mid-line (Black); this error is not of real practical importance. The sigmoid flexure is liable to great variation in length of its meso-colon, and therefore in position. In the rare condition of extroversion of the cloaca the hindgut is so mal-developed as to be almost unrecognizable.

DISEASES OF THE PERITONEUM

PNEUMOCOCCAL PERITONITIS

Pneumococcal peritonitis is probably the most fatal acute disease with which the surgeon has to deal. When to this consideration we add the fact that the ravages of the disease are practically confined to the period of childhood, we can appreciate that the infection must possess peculiar interest for every pediatric surgeon.

VARIETIES OF THE DISEASE. It is important to recognize a classification of the disease which is in keeping with both clinical and experimental evidence. There are two main types, *primary* and *secondary pneumococcal peritonitis*, the distinction being that in the primary type the peritoneal infection is the original, and for a time the only, manifestation of the disease, while in the secondary type the

sometimes falling into intervals of unconsciousness, the temperature went slightly higher. It was apparent that an intense general infection was now present in addition to the local manifestations.

Case III Example of a chronic primary Pneumococcal Peritonitis

A female child, aged 10 years. The illness extended over a period of three weeks before admission to hospital, and previous to this a vaginal discharge had existed. The onset of the disease was marked by colic like pains in the lower abdomen, followed in a short time by profuse diarrhoea and intermittent attacks of vomiting. During the first week of the illness the trio of symptoms continued, but that they were not of extreme urgency may be inferred from the fact that during this time the child was not entirely confined to bed.

During the second week of the illness the symptoms continued, the pain was still a prominent feature, but the diarrhoea and vomiting became less marked. During this week bodily weakness became noticeable, and there was considerable loss of flesh. She was now confined to bed.

With the commencement of the third week the diarrhoea abated, and a new feature made its appearance in the shape of a tender swelling in the lower abdomen. At this time, frequency of and pain on micturition appeared, while there were recurrent attacks of colic.

The child was admitted to hospital exactly three weeks after the onset. A summary of her condition on admission may be expressed as follows: a pale emaciated girl. Her general appearance was one of extreme nervous irritability. The mouth and lips were dry, the temperature was 102° , and the pulse rate 120. Abdominal examination showed a rounded tender swelling extending in the middle line to the level of the umbilicus and filling the pelvis. There was a leucocytosis of 20,000, and a well marked glycogenic reaction. Laparotomy showed the presence of an encysted abscess in the pelvis and lower abdomen, its contents were in keeping with a pneumococcal infection, and pneumococci were isolated from the exudate.

A Correlation of the Clinical Features. Though apparently distinctive in their respective features, the three cases above recounted are evidences of different degrees of the same infection. A typical acute case begins as a pelvic peritonitis, and at this stage there is supra pubic pain with pain on micturition and diarrhoea, the result of inflammatory irritation of the rectal and vesical walls. The infection then tends to become a general peritonitis, with an aggravation of symptoms and signs both local and general.

A further development may now appear, which gives the disease its distinctive character, and also its deplorably high mortality, a general invasion of the blood stream by the pneumococcus. This intense pneumococcal septicæmia explains the dramatic change in the patient's appearance, the cyanosis, the delirium, the loss of consciousness, and the collapse.

CLINICAL FEATURES

We have said that three clinical varieties of the disease are demonstrable—fulminating, acute, and chronic, and in each the history is distinctive. A description of the clinical history is best given by recounting actual case histories typical of each class.

Case I. Example of fulminating Pneumococcal Peritonitis.

A female child, aged 6 years, was admitted to hospital on account of severe abdominal pain, persistent vomiting, and general prostration. The duration of the illness before admission only extended over twenty-four hours. In the morning the child had appeared to be in excellent health, and partook of a hearty breakfast. At 10 a.m., while playing with her companion, she suddenly complained of severe abdominal pain, and half an hour later she was violently sick. She was put to bed, and throughout the day the pain continued, while the vomiting was persistent. During the night these features continued, but she made very little complaint, and in the morning her condition was one of collapse, with intervals of complete unconsciousness.

In this condition she was admitted to hospital. On admission she was unconscious—there was slight general cyanosis, temperature was 103°, the pulse uncountable, and the respiration rate 50. The abdomen was rigid in its lower half; below the umbilical plane, the percussion note was dull. On account of the loss of consciousness it was difficult to estimate the question of pain, but there appeared to be tenderness in both iliac fossæ.

Operation revealed an intense peritonitis most marked in the lower abdomen. From the exudate pneumococci were isolated.

Within thirty-six hours of the onset of the illness the child succumbed. The case throughout presented the most intense features.

Case II. Example of acute primary Pneumococcal Peritonitis.

A female child aged 4½ years. A persistent vaginal discharge had existed for some weeks. The illness began with the complaint of low abdominal pain, not intense, but somewhat colicky in character. With the pain there were fever and general malaise.

Twenty-four hours later the child continued to complain, but the pain was now more generalized, and additional features had made their appearance—there was pain on micturition, with a tendency to retention of urine, diarrhoea, with intervals of tenesmus and vomiting. The general illness remained, and the temperature reached the high level of 105°.

During a further interval of twenty-four hours the clinical features remained somewhat similar, though the pain was now general, and the vomiting more persistent. The clinical picture then altered, and it did so with comparative suddenness. The appearance became cyanosed, the respiration rate rapidly increased, the child became delirious,

In the *chronic variety* of the disease the condition is often confused with tuberculous peritonitis. The early acute signs may have been forgotten or misinterpreted, an abdominal abscess makes its appearance, and in the course of time, if neglected, it points at the umbilicus as a chronic abscess. The sequence is easily ascribed to a tuberculous infection, but examination of the pus and the completeness with which the disease eventually disappears will reveal its true character.

PROGNOSIS

The mortality of the disease is a high one, and it is the development of a septicæmia which brings the fatal issue. It is doubtful whether an example of the fulminating type ever recovers, in the acute variety, the prognosis will depend upon whether the septicæmia can be arrested or minimized (a mortality of about 60 per cent is the average experience), the chronic type of the disease is, of course, much more hopeful, because the septicæmic stage is either averted or diminished, and a mortality of 10 to 15 per cent is usually recorded.

TREATMENT

Early operative treatment offers the best prospect of success, but even so the outlook is extremely grave. The very high mortality has induced certain surgeons to claim that it is better to delay operative interference in the hope that the disease may ultimately become so localized that simple incision of an abscess may be all that is eventually required. The criticism of such a view is that, while the system of temporizing is being practised, a considerable number of cases will be lost, and it will resolve itself into a survival of the fittest. The results of early operation are incomparably better than those obtained by delay.

The Operation. Simple drainage is all that is required. The abdomen is opened in the middle line so as to permit drainage of the pouch of Douglas, and in many cases good results have been obtained by using the vaginal route. Either local anæsthesia or gas and oxygen anæsthesia should be employed, chloroform or ether must be rigidly excluded, because of their toxic and depressing effects. A glass tube or a rubber drain carries away the effusion. Thereafter large thick fomentations are applied to the surface of the abdomen and, in order to be effective, these applications must be kept continuously at as high a temperature as possible, this being secured by the frequent changing and the use of specially thick fomentations.

The child is meantime encouraged to drink large quantities of fluid, and pain is kept in abeyance with a suitable hypnotic.

In view of the extremely serious outlook any adjunct which promises to improve the prospect may be adopted, and pneumococcal sera or phylacogens may therefore be given a trial.

Treatment is continued on these lines, and a careful watch is kept

If the patient should survive this stage, a series of pulmonary affections develop—the circulation of organisms through the lungs results in a multiple broncho-pneumonia, patches of pleurisy appear, and an empyema may develop.

It is helpful therefore to trace the sequence in a characteristic case, for it is by so doing that we realize the extreme seriousness of the disease. A pelvic peritonitis passes into a general peritonitis, at a certain stage the local infection results in an invasion of the blood stream, and an intense septicæmia supervenes, and, if this is survived, it leaves infective elements in the lungs, which are responsible for a series of pulmonary complications. Such being the sequence in the typical acute case, the fulminating and the chronic cases are modifications of the more common acute type. In the fulminating variety a septicæmia occurs either coincident with or shortly after the local infection has become established; hence the startling suddenness of the disease and the almost inevitably fatal result. In the chronic variety the infection has remained as a local pelvic peritonitis, there has been no septicæmia, and the eventual development is a localized pelvic abscess.

PATHOLOGY

The early pathology of the disease is that of an acute pelvic peritonitis; the viscera are covered with a sticky exudate, there is congestion of the underlying organs, and it may be possible to demonstrate a purulent infection of the Fallopian tubes. After twenty-four hours, the exudate becomes watery and profuse, it is of a brownish colour, and flakes of lymph and fibrin are mingled with it. It is only during and after the fourth day that the exudate becomes definitely purulent.

An observer is impressed by the comparative absence of a proper attempt at localization of the disease, a distinction which is so different from the majority of peritonitis cases.

At a later stage the pathology is that of a septicæmia, with its widespread septic changes, and, at a later date, empyema or a broncho-pneumonia will most likely be found. As in pneumonia, the urine chlorides and the blood chlorides are diminished.

DIAGNOSIS

The recognition of the *fulminating type* of the disease is often extremely difficult; the general symptoms are so intense that they overshadow the local signs, and the condition is ascribed to ptomaine poisoning.

The ordinary *acute variety* is generally recognized as a peritonitis, but it is more difficult to classify the exact type of the infection. Suspicion should be aroused by the apparent pelvic origin of the disease in a girl, and in this respect diarrhœa and painful micturition are important. When the disease reaches the septicæmic stage there is little room for doubt.

In the *chronic variety* of the disease the condition is often confused with *tuberculous peritonitis*. The early acute signs may have been forgotten or misinterpreted, an abdominal abscess makes its appearance, and in the course of time, if neglected, it points at the umbilicus as a chronic abscess. The sequence is easily ascribed to a tuberculous infection, but examination of the pus and the completeness with which the disease eventually disappears will reveal its true character.

PROGNOSIS

The mortality of the disease is a high one, and it is the development of a septicæmia which brings the fatal issue. It is doubtful whether an example of the fulminating type ever recovers, in the acute variety, the prognosis will depend upon whether the septicæmia can be arrested or minimized (a mortality of about 60 per cent is the average experience), the chronic type of the disease is, of course, much more hopeful, because the septicæmic stage is either averted or diminished, and a mortality of 10 to 15 per cent is usually recorded.

TREATMENT

Early operative treatment offers the best prospect of success, but even so the outlook is extremely grave. The very high mortality has induced certain surgeons to claim that it is better to delay operative interference in the hope that the disease may ultimately become so localized that simple incision of an abscess may be all that is eventually required. The criticism of such a view is that, while the system of temporizing is being practised, a considerable number of cases will be lost, and it will resolve itself into a survival of the fittest. The results of early operation are incomparably better than those obtained by delay.

The Operation. Simple drainage is all that is required. The abdomen is opened in the middle line so as to permit drainage of the pouch of Douglas, and in many cases good results have been obtained by using the vaginal route. Either local anæsthesia or gas and oxygen anæsthesia should be employed, chloroform or ether must be rigidly excluded, because of their toxic and depressing effects. A glass tube or a rubber drain carries away the effusion. Thereafter large thick fomentations are applied to the surface of the abdomen and, in order to be effective, these applications must be kept continuously at as high a temperature as possible, this being secured by the frequent changing and the use of specially thick fomentations.

The child is meantime encouraged to drink large quantities of fluid, and pain is kept in abeyance with a suitable hypnotic.

In view of the extremely serious outlook any adjunct which promises to improve the prospect may be adopted, and pneumococcal sera or phylacogens may therefore be given a trial.

Treatment is continued on these lines, and a careful watch is kept

for the earliest evidence of a septicæmic development, and evidence suggestive of this calls for a further line of treatment.

On the earliest signs of septicæmia the child is given an intravenous infusion of citrated blood, the amount given depending on the age of the child—400 to 500 c.c. is a common average. The infusion must be given carefully and slowly, lest it throw too great a strain upon an already weakened heart muscle. On the suggestion of the late Mr. Bruce Robertson, of Toronto, we have sometimes exsanguinated a child before introducing the fresh blood, and this modification has promised considerable success. If the blood transfusion is to give the maximum of benefit, the moment of its administration must be carefully chosen; if given too early it may not prevent the development of the septicæmia, while, if administered when the septicæmia is intense, its action is largely valueless. The crucial time is at the first sign of the development of the blood infection. Apart from the transfusion, the stage of septicæmia is treated by the exhibition of stimulants and by the free use of oxygen.

Secondary Pneumococcal Peritonitis

This variety of the disease is most characteristically seen in children who are suffering from pneumonia complicated by empyema. From the extra-abdominal focus there is an extension of the disease into the peritoneal surface, so that a peritonitis results.

The manifestations of the disease are very different from those encountered in the primary variety. The infection is of a comparatively mild and slowly spreading character, early localization occurs, and the formation of a circumscribed abscess is the usual sequel.

CLINICAL FEATURES. In association with an extra-abdominal pneumococcal lesion the child begins to complain of abdominal pain, there is a further rise of temperature, local tenderness is evident on pressure, when there may be vomiting and localized distention.

TREATMENT. In view of the tendency which there is for the disease to become localized, surgical interference should be delayed until abscess formation occurs; the focus is then dealt with by incision and drainage. If it is evident that the disease is spreading, laparotomy may be called for at an earlier stage.

Streptococcal Peritonitis

Scarlet fever may be associated with the development of a general streptococcal peritonitis. Similarly any streptococcal septicæmia may be complicated by a peritoneal infection. The disease is a peculiarly fatal one, and drainage of the abdominal cavity is the only surgical procedure which is of any avail.

THE SURGICAL ASPECTS OF ABDOMINAL TUBERCULOSIS

The alimentary tract is one of the common sources of entrance of the tubercle bacillus into the body of the child, and it is therefore not surprising that peritoneal and visceral manifestations of the disease are frequent. It is in the small intestine, and particularly in the lower end of the ileum that the absorption of the infecting organisms occurs, and in this connection it is important to recall that Dunn and others have demonstrated that the organisms may pass through the intestinal wall and yet leave no pathological change which can be recognized as an evidence of their passage—in fact, tuberculous ulceration of the intestinal mucosa is uncommon in the child.

By their passage through the intestinal wall, the organisms gain entrance to the abdominal cavity, and it is from this point that demonstrable lesions become apparent. The organisms may pass *via* the lymphatics into the glands, when tuberculous lymphadenitis ('*tuberculosis mesenterica*') results, or they may pass by a route which as yet is obscure, but which results in a localized or a diffuse involvement of the peritoneum—*tuberculous peritonitis*. These two conditions call for separate consideration.

Tuberculosis Mesenterica

There are probably comparatively few children who escape some degree of tuberculous infection of the abdominal glands, but in the majority of cases the lesion is circumscribed, and a natural resistance results in fibrosis and calcification. In less fortunate cases the disease extends, and large masses of tuberculous glands are manifest within the abdominal cavity; they appear in the mesentery of the ileo-cæcal angle, and at the root of the mesentery of the small intestine.

The pathology is similar to that of tuberculous adenitis in any other situation, but, owing to the constant absorption of pyogenic organisms from the intestinal tract, tuberculous mesenteric glands are apt to undergo repeated attacks of sub-acute periadenitis or of lymphadenitis. It would seem that the destruction of active lymphatic tissue, which naturally follows the tuberculous infection, reduces the resistant power of the gland, and the manifestations of organismal infection are therefore more frequent and more intense. It is this fact which probably explains the readiness with which tuberculous abdominal glands undergo caseation.

The surgical significance of tuberculosis mesenterica may be summarized as follows—

- 1 The disease may give rise to difficulties and errors in diagnosis.
- 2 It may be the means of producing a condition of acute intestinal obstruction.
- 3 The gland infection may lead to the more serious manifestation of tuberculous infection of the peritoneum.

TREATMENT. The condition rarely demands surgical interference. If it is met with during the course of an abdominal operation, and if only a single mass is found to exist in an accessible situation, its removal would be an advantage. It is a mistake to incise the gland and to attempt to curette its interior—general peritoneal infection may result from such interference.

If a mass of glands in the ileo-cæcal angle is producing a chronic intestinal obstruction it may be necessary to short-circuit the loop of bowel which is related to the disease. If this operation is done the result will be an interesting demonstration of the beneficial effect of physiological rest upon a tuberculous lesion. Apart from these considerations, abdominal glandular tuberculosis is most efficiently treated by conservative and medical measures.

Tuberculous Peritonitis

Tuberculous peritonitis is a serious manifestation of abdominal tuberculosis. It is generally accompanied by coincident or preceding infection of the mesenteric glands, and in the majority of cases it is accompanied by other manifestations of the disease throughout the body.

VARIETIES. It is convenient to classify various types of the disease as manifested on a pathological basis.

- (1) The *ascitic* form, in which the eruption of tubercles on the peritoneum is accompanied by the effusion of fluid either into the general peritoneal cavity or into an area which has been localized by adhesions.
- (2) The *adhesive* form, in which there is a matting together of the various coils of intestine by tuberculous granulation tissue.
- (3) The *acute* form, in which the clinical features are so intense as to simulate a pyogenic peritonitis. The congested peritoneum is covered with tubercles, and a plastic deposit appears on its surface.
- (4) The *purulent or caseous* form, in which adhesive peritonitis is present, but between the adhesions, and often between individual loops of bowel, there are quantities of caseous débris or pus.

CLINICAL FEATURES. The early symptoms of tuberculous peritonitis are often obscure; sometimes the features appear so abruptly as to simulate an acute peritonitis, and the similarity may lead to considerable diagnostic difficulty. In the average case the symptoms are indefinite abdominal pain, emaciation, loss of appetite, constipation with occasional attacks of diarrhoea, and a moderate evening rise of temperature.

The abdomen is tumid, the surface temperature is raised, and the superficial veins are engorged as the result of venous obstruction in the interior. The abdomen is tender to touch, it has a doughy, elastic

sensation, and individual tumours may be palpable. In some cases the indurated contracted omentum gives the impression of a sausage shaped tumour stretching across the abdominal cavity above the umbilicus. Ascites, localized or general, is common. In the caseous variety a redness around the umbilicus indicates that the intra abdominal suppuration is beginning to make its way to the surface. The pinched face, the wasted limbs, the general discomfort and fretfulness, and the local abdominal signs form a characteristic clinical picture.

THE SURGICAL TREATMENT

The majority of cases of tuberculous peritonitis respond to medical treatment, and it is only under special conditions that surgical intervention is advisable. The indications for surgical treatment may be summed up under the following headings —

- (1) The ascitic type of tuberculous peritonitis is frequently benefited by a simple *cœliotomy*.
- (2) The caseous type of tuberculous peritonitis may demand incision in order to liberate a localized collection of pus.
- (3) In any variety of tuberculous peritonitis, and most frequently in the adhesive type, the development of an acute intestinal obstruction may necessitate a laparotomy.

(1) *Cœliotomy for Tuberculous Ascites* If conservative and medical measures have failed to produce improvement, and if the accumulation of fluid is becoming so great as to give rise to embarrassment, *cœliotomy* and complete evacuation of the fluid is a more efficacious procedure in the child than repeated *paracentesis*. The abdomen is opened through a small sub umbilical incision, and, in order that the abdominal wound may be as strong as possible after closure, a paramedian incision with displacement of the rectus muscle is chosen—mid line incisions are avoided. The peritoneal cavity is entered with care in case bowel is adherent to the deep surface of the abdominal wall, the free fluid is emptied as completely as possible by means of long handled mops, and the wound is closed. It is the practice of some to pass free oxygen into the abdominal cavity immediately before the last stitch is tied, the closure of the last suture retaining the gas within the abdomen. A small amount of iodoform in saline (1 in 10,000) has sometimes been used with apparent benefit, but we have always been satisfied with simple evacuation of the fluid.

The benefit which results from *cœliotomy* would appear to proceed from the fact that after removal of the fluid from the peritoneal cavity serum with anti bacterial properties collects, and the morbid process may be thereby arrested.

(2) *Incisions in the Caseous Type* If redness appears around the umbilicus it is advisable to incise the area, to liberate the pus, and

to introduce an iodoform preparation into the cavity, thereafter closing the wound. In this way the advent of a fæcal fistula may be arrested, but the operation must be carried out with the greatest care, because rough or careless manipulation may result in perforation of the bowel and the establishment of a small intestine fistula.

(3) **Acute Obstruction in Tuberculous Peritonitis.** This is one of the most difficult and hopeless conditions with which the surgeon has to deal. The complication generally arises in the adhesive type, and it is the matting together of the various coils of bowel which makes any effective treatment difficult. The obstruction is a small intestine one; a fistula therefore is to be avoided at all costs, and the best procedure which the surgeon can adopt is either an entero-anastomosis or an anastomosis between small and large bowel.

It is most convenient to open the abdomen in the right para-median line, the most distended coil of bowel is assumed to indicate a point immediately above the obstruction, and the surgeon must use his judgment in estimating the best form of anastomosis to employ. As a rule it is unwise to attempt any widespread separation of intestine—no benefit is likely to result, and the risk of perforating the bowel is considerable.

A SYNOPSIS OF THE VARIOUS MEDICAL MEASURES WHICH ARE ADOPTED EITHER INDEPENDENTLY OR IN COLLABORATION WITH SURGICAL TREATMENT

The first essential in this as in other forms of tuberculosis is to place the child in the most favourable surroundings, where he may have abundance of fresh air and as much sunshine as may be. Food should be abundant and nourishing, fresh cow's milk being the best article of diet. When the sun is shining the child should lie with the abdomen uncovered, and at other times artificial heliotherapy should be arranged for.

We advise the administration of Bereneck's tuberculin, given on the plan which has been described elsewhere (p. 119), or Moro's ointment may be used.

A great variety of local methods of treatment have been advocated. The abdomen may be painted with iodine paint once a day, or every alternate day, according as it is borne, olive oil being smeared over the part as soon as the iodine is applied, in order to prevent evaporation; an ointment composed of equal parts of iodoform ointment and cod liver oil may be rubbed into the abdomen twice daily; good results have been recorded from the use of linimentum hydrargyri, the liniment being spread over the surface of a flannel belt which is stitched around the abdomen.

Internally cod liver oil is the favourite remedy; it is often beneficial to give $\frac{1}{2}$ to a $\frac{1}{4}$ grain of iodoform dissolved in a dessertspoonful of cod liver oil after food twice a day. Continental physicians advocate the use of creasote given in enemata, beginning with 3 minims

increased gradually to 15 minims in $\frac{1}{2}$ ounces of emulsified cod liver oil, once daily

TUBERCULOUS DISEASE OF THE INTESTINAL WALL

Children, in common with adults, suffer from tuberculous infection of the bowel wall. In view of the large part played by the alimentary tract in the infection of the child it might be thought that tuberculosis of the bowel wall would be more common in the child than in the adult, yet such is not the case. peritoneal and glandular manifestations are those most commonly found in the child, while the infections of the bowel wall are more frequent in the adult. The peculiarity is difficult to explain, unless it be that the rapid absorption through the bowel wall of the child does not permit sufficient time for the organism to settle. But even in the child the condition occurs sufficiently frequently to demand recognition.

PATHOLOGY Two types of the disease are recognized—one acute in its progress, ulcerating and destructive in its characters, affecting the sub mucous layer of the bowel and afterwards invading and destroying the mucous coat and the muscular layer, the other chronic in its course, hyperplastic in its characters, associated with the formation of masses of granulation tissue throughout the coats of the bowel wall, and ending in a tumour formation of varying size.

The ulcerating type of the disease is uncommon in the child. It is met with in cases of general tuberculosis, and as a sequel to advanced pulmonary tuberculosis when the swallowed sputum is the source of the infection. The treatment is essentially of a medical nature.

The hyperplastic type of the disease is the manifestation most commonly displayed in the child, and, as tumour formation and stricture are often the sequelæ of its development, surgical treatment is frequently demanded.

The ileo caecal segment of the bowel is the common site of infection, and the predisposition depends upon anatomical and physiological reasons, for this is a region of delay, and a region in which the occurrence of lymphatic tissue forms foci for the development of the disease. Tuberculous nodules form in the sub mucous layers of the bowel, the disease infiltrates throughout the layers of the intestinal wall, and a reactive formation of connective tissue arises, which results in a mass of granulation tissue, or, if fibrous changes develop, in an annular stricture. If the serous coat of the bowel is unaffected, the tumour remains mobile, but in disease of long standing, fixation is likely to be present. If the ileo caecal angle is the site of the disease, the appendix may be incorporated in the general mass. In certain cases, the appendix would seem to be the original site of the lesion.

CLINICAL FEATURES In the early stages of the disease, definite symptoms are absent. There are occasional complaints of colic, the digestion may be upset from time to time, while in some cases the

recognition of a tumour is the first real evidence of the disease. Where hospital practice is concerned, many of these cases come first under the care of the surgeon because the signs of acute intestinal obstruction have developed. In a characteristic case, if skilled observation is possible before complete obstruction develops, peristaltic patterns may be observed, or there may be a history of attacks of abdominal distention relieved by purgation or enemata. Gurgling and borborygmi may be audible, and they are often increased by examination. Palpation of the abdomen may reveal the presence of the tumour and the occurrence of enlarged mesenteric glands.

DIAGNOSIS. Chronic appendicitis, with or without the presence of an abscess, is practically the only condition of childhood which resembles the disease. The relative histories are usually sufficiently distinctive to prevent error. In certain cases the diagnosis may not be clear until operation is performed.

TREATMENT. Operation is indicated if there are any signs suggestive of intestinal obstruction, for it is well to forestall an acute block. The choice of operation lies between resection of the tumour with subsequent anastomosis, or a short-circuit of the affected area. In our experience resection is rarely necessary; it is only indicated in the event of perforation of the bowel by the disease, and as this complication is exceedingly rare, a short-circuit operation meets the needs of the majority of cases. A unilateral exclusion of the affected segment of bowel is done, and it is an interesting demonstration of the value of physiological rest in the treatment of tuberculosis when it is found that some months after the short-circuit operation has been performed the original tumour mass has disappeared. In view of this it is usually inadvisable to practise the graver operation of resection and anastomosis.

THE STOMACH

CONGENITAL HYPERTROPHY OF THE PYLORUS

Definition. Congenital hypertrophy of the pylorus is a well-recognized disease of early life, in which a hypertrophy of the muscular coat of the pylorus and adjacent stomach wall is associated with signs of pyloric obstruction.

ETIOLOGY

Boys are more commonly affected than girls in a proportion of about ten to one. In isolated cases evidence is obtained of family occurrence of the disease, but the evidence is probably no more than a coincidence. In 50 per cent. of cases a first-born child is the affected member.

The real problem of the etiology, however, is the explanation of the muscular hypertrophy which is responsible for the obstructive symp-

toms Examination shows that the essential change is a true hypertrophy of the muscular tissue at the extremities of the stomach, the most evident thickening being found at the pylorus and the stomach wall in immediate relationship to it, but a lesser degree of a similar change is found at the cardiac orifice and in the lower end of the œsophagus The various explanatory theories which have been put forward may be summarized into two opposing views —

- (1) That there is a primary congenital muscular hypertrophy in the affected region, and that this is associated with a secondary increased functional activity, the combination resulting in a pyloric obstruction (Hirschsprung Cantley)
- (2) That a functional over activity of the muscle is the primary factor, that the functional error depends upon a want of co ordination of the normal stimuli, and that the repeated forcible contractions of the muscle result in a secondary hypertrophy (Thomson)

At the present time the second view meets with the greatest acceptance, and, in elaboration of it, it is assumed that the want of co ordination actually begins before birth, when the activity of the stomach and the pylorus is stimulated by the swallowing of liquor amni It is perhaps unwise, however, to dogmatize upon the congenital nature of the disorder, for what is congenital may only be a lack of stability in the harmony between gastric and pyloric contraction and relaxation Whatever view be accepted, it is important to realize that the obstruction results from a combination of two errors—the increased bulk of the muscular fibres, and the powerful contraction of the hypertrophied muscle

PATHOLOGY

From the level of the pyloric veins the muscular hypertrophy extends proximally along the stomach wall to the neighbourhood of the incisura angularis, where the normal thickness of the muscular wall is gradually reached The hypertrophy extends in a very slight degree into the first part of the duodenum, but the pyloric canal and the pyloric vestibule are the chief sites of the change We believe that the circular pyloric sphincter is not affected by the hypertrophy The muscular overgrowth forms a firm swelling of a paler colour than the remainder of the stomach wall, the overlying peritoneum is tense, the hypertrophied muscle is of varying thickness, is greyish white on section, with a diminished vascularity, and, when divided with a knife in the long axis of the stomach, it instantly retracts, for the circular fibres are those which are mainly affected by the hypertrophy The sub mucous coat appears to be increased in thickness, and the fact has a bearing upon the operative treatment, because the peculiarity permits of easy separation of the muscular from the underlying mucous coat The mucous membrane is often invaginated in a U shaped manner into the lumen otherwise its structure is unaltered The body of the stomach is dilated and catarrhal changes are generally manifest throughout the lining mucosa

The surgeon early appreciates that when there is much retention of contents within the stomach the pyloric tumour shows evidences of oedema with a temporary increase in size. The change probably depends upon a mild infective process extending into the stomach wall as the result of the retention of contents. Clinically the phase of oedema corresponds to an exacerbation of the obstructive symptoms.

SYMPTOMS

In a typical case the history is characteristic. For a week or two after birth the child enjoys good health, vomiting then begins to appear, and the mother is at a loss to explain the development, for no dietetic error appears to be responsible. At first the vomiting is that



FIG. 431 —Congenital Hypertrophic Stenosis of the Pylorus (Baby 3½ months).

of ordinary sickness, but after the symptom has persisted for a short time it acquires characteristic features, in that it becomes forcible and explosive, so that it shoots from the nose and mouth. The vomited matter is often large in amount, suggesting that it represents more than a single meal. The vomiting may come on immediately after the meal has been taken, or an interval of five or ten minutes may elapse. Meantime the child shows no general evidence of dyspepsia, and his appetite is unimpaired. While the symptom of vomiting is persisting, however, the child is losing weight, and the rapidity with which the weight is falling is a valuable index to the degree of pyloric obstruction which exists.

In the absence of suitable treatment the vomiting continues, and, because an insufficiency of food is being ingested, the body weight steadily falls, and constipation becomes evident.

EXAMINATION OF THE BABY

In the early stages of the disease the child has a healthy appearance, and there are no evidences of dyspepsia. When the symptoms have existed for some time there is general wasting and other evidences of inanition.

Abdominal examination shows some fullness in the upper part. If the baby is given some fluid, and the abdomen is then palpated or kneaded, a pattern of the stomach may be seen to frame itself on the abdominal wall. It appears as a rounded swelling beneath the left costal margin, and becomes more definite and rounded in its outline until it is about the size of a golf ball. This swelling gradually passes from left to right across the abdomen and then disappears. Successive patterns of this nature succeed one another at intervals of a few seconds, and, if a careful palpation is made at the point where the pattern seems to disappear, the rounded tumour of the hypertrophied pylorus may be made out. In many cases the recognition of the

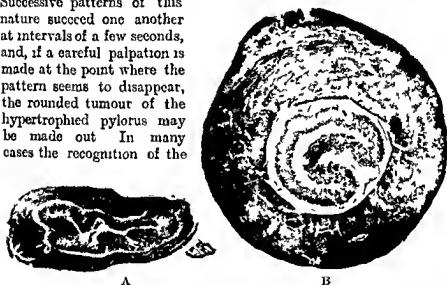


FIG. 432.—A Normal Pylorus in cross section (Baby 9 weeks old). B Congenital Hypertrophy of Pylorus in cross section to show the remarkable hyperplasia of the circular muscular coat.

(These sections are shown by permission of Dr. John Thomson.)

tumour is difficult, but if sufficient care is taken it should always be demonstrable, palpation should be done while the child is having a feed, because at this time the pylorus is most easily felt.

DIAGNOSIS

A gastric catarrh with secondary pyloric spasm and a congenital duodenal obstruction are the two conditions liable to be confused with hypertrophy of the pylorus. A true pyloric obstruction is recognized by the characteristic clinical history, the demonstration of a gastric pattern, and the palpable pylorus, and in the presence of these features there need be no dubiety in the diagnosis. The constipation and the vomiting of meningitis are sometimes a source of confusion.

PROGNOSIS

When the condition is untreated or progressive, the symptoms increase in severity, wasting becomes rapid, and, though the vomiting may diminish, symptoms of severe gastro-intestinal catarrh supervene, and the child succumbs to exhaustion and inanition.

TREATMENT

There are many who hold that the treatment should be inaugurated by a course of medical treatment. In the majority of cases this is followed by an amelioration of symptoms, and, even though no definite general improvement is obtained, the infant is probably in a better condition for subsequent surgical operation. The important fact in relation to medical treatment is that it must not be persisted in too long if improvement is not apparent. Sometimes it is persevered in with an unreasonable optimism until the child is so debilitated that surgical operation holds but small prospects of success.

Any detailed account of the medical treatment is unnecessary in a work of this description, but briefly it entails feeding the infant every two hours with a suitable fluid, such as peptonized milk and water, or diluted mother's milk if the baby is breast-fed, and daily lavage of the stomach with a mild alkaline wash. The child is carefully weighed each day, and a weight chart is kept.

There are undoubtedly a number of cases in which painstaking and efficient regulation of the diet in the direction of reducing the food to small quantities at short intervals has resulted in a gradual disappearance of the tumour and of the peristalsis, but the cure has been at the expense of weeks or even months with the child hovering on the verge of collapse.

The introduction of lavage has improved the non-operative results, but it too has a large element of uncertainty. At the best it is only after many weeks of daily lavage, usually twice daily for a time, and then once daily, that the condition is cured. Moreover, the method has real disadvantages, which it is well to appreciate: many babies do not tolerate lavage well, they become so collapsed and exhausted that the treatment has to be abandoned, and in a certain proportion of cases it appears to induce a regrettable amount of gastric irritation. With all its disadvantages, however, lavage has had sufficient success to justify its use as a method of treatment in certain cases.

*Surgical Treatment**Indications.*

A wide diversity of opinion has existed, and will continue to exist, as to the question of when operation should be resorted to. When the problem arises the practitioner will do well to consider certain facts, and, having considered them, to accept certain indications as strongly supporting operation.

The general facts are —

- (1) The operation, of whatever nature it may be, is often fatal
- (2) The best results will be obtained by the surgeon who has had considerable experience in the conduct of these cases
- (3) If the case is one in which the choice between surgical and medical treatment is a narrow one, the decision should be given to operation

Apart from these general facts there are certain conditions which the majority are agreed should be accepted as indications for operative treatment. These are —

- (1) If in spite of a fair trial by medical means, the child's weight continues to fall
- (2) If the child, when first seen, is in a collapsed condition
- (3) If the child is a breast fed baby. This last indication requires some further explanation

The choice of medical treatment in a breast fed baby will almost certainly mean the sacrifice of the mother's milk. The weeks or months of medical treatment, the prolonged anxiety, and the disturbance of suckling, make it almost impossible to retain the mother's milk, and therefore in these cases it is our invariable practice to advise that operation be carried out, for within twenty four hours the child may resume breast feeding

Varieties of Surgical Treatment

A variety of operations have been practised from time to time, many of which have been abandoned by common consent—pylorectomy, pyloroplasty, and gastro enterostomy are now things of the past. The present day procedures may be said to be included under three headings —

- (1) *Forcible dilatation of the pylorus (the modified Loreta operation)*
- (2) *The Rammstedt operation*
- (3) *The Strauss modification of the Rammstedt operation*

(1) **Forcible Dilatation of the Pylorus** The method is an extremely simple one. The abdomen is opened by a small incision to the right of the middle line, this position being chosen because the gastric distention which exists displaces the pylorus well over to the right. The pylorus and the pyloric portion of the stomach are gently pulled out of the wound and protected by warm saline packs. A small incision is now made into the stomach, and it is important that it should not be made through a hypertrophied portion of the stomach wall, because in that event its subsequent closure may be difficult. A special dilator is introduced into the stomach cavity and, guided by the operator's left hand, it is passed through the pylorus until its point can be felt in the first part of the duodenum. By means of the dilator

the pylorus is now stretched in much the same fashion as one stretches a glove finger. The divulsion is carried out gradually, and, as a matter of fact, surprisingly little force is required. Certain surgeons use bougies to stretch the pylorus, while others employ the finger as a stretching medium. When the operator is satisfied that the obstruction has been completely overcome, the stomach wound is sutured, and the abdominal wound closed with a series of interrupted silkworm gut sutures.

(2) **The Rammstedt Operation.** The abdomen is opened by a right paramedian incision about $1\frac{1}{2}$ inches long, the pylorus is delivered and rotated so that its upper surface looks directly forwards. The tumour is incised longitudinally from end to end through the bloodless area above the level of the pyloric vein. The incision is made with a very sharp small-bladed knife, and it is carried down to, but not into, the sub-mucosa, which shows up as a yellowish-white glistening surface.

Great care is required when the incision comes close to the duodenum, because of the liability to injury of the duodenal mucous membrane from its proximity to the muscular coat. Separation of the divided surfaces is completed by inserting the closed blade of a small blunt scissors between the edges, and gradually opening the blades. It is important to assure oneself that no muscular tissue has been left undivided. It is unlikely that any bleeding of consequence will ensue, but, if any hæmorrhage is apparent, it must be arrested, however slight it may appear, for there is little tendency to spontaneous coagulation. The bleeding is controlled by undercutting the vessel with a small round needle and fine catgut, or by implanting a tag of omentum or a shred of muscle over the bleeding point.

The viscera are now returned to the abdomen, and the wound in the abdomen wall is closed with interrupted silkworm-gut sutures.

(3) **The Strauss Modification of the Rammstedt Operation.** A. A. Strauss has devised an operation which, in his hands, has given excellent results with a mortality of only three deaths in one hundred and three consecutive cases. This operation is based on experimental work done by Strauss in 1912 and 1913. According to his technic an incision about 1 inch long is made through the fibres of the rectus muscle in the right hypochondriac region over the pylorus, and if a tumour can be felt the location of the incision is rendered more accurate. The index finger is inserted through the incision, and a ribbon-shaped hook is introduced into the wound along the index finger to the hypertrophied pylorus, which is brought up into the wound by this hook. If this cannot be readily done or a hook of this type is not available, the incision may be enlarged until the pylorus can be delivered into the wound without difficulty. The practice of Strauss, however, is to deliver the pylorus by this hook, working through a small incision in order to avoid unduly exposing the other portions of



A

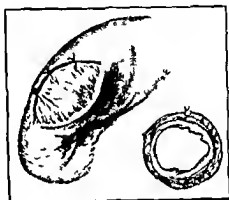
FIG 433—Operations for Congenital Stenosis of the Pylorus (After Horsley)

A The Rammstedt operation

B C The Rammstedt as modified by Strauss
(After Horsley)



B



C

the stomach or the intestines. After delivering the tumour, an incision is made into the bloodless region of the pylorus. This incision is longitudinal, and is made with a sharp knife, going through only the superficial layers of the hypertrophied muscle. The rest of the fibres are separated with the handle of a scalpel to the stomach side of the growth, where it merges into the normal musculature of the stomach. Working close to the mucosa of the stomach in this manner and in this region gives a line of cleavage between the mucosa and the muscular coat that is easily obtained, and makes it possible to split the hypertrophied muscle down to the duodenum without the accident of puncturing the mucosa, is a danger in the usual method of performing the Rammstedt operation. The edges of the divided hypertrophied muscle fibres are caught and pulled apart with the fingers and thumb, using a piece of gauze to secure a firm hold. This causes the mucosa to separate from the muscular coats in the stomach, and also breaks the few remaining muscle fibres toward the duodenal end. These fibres are often responsible for constriction, and, when divided with a knife, injury to the mucosa of the duodenum is likely to occur. By this method they are torn apart instead of being cut. The mucosa is completely shelled out by blunt dissection from the muscular layers of the hypertrophied pylorus. This causes the mucosa to unfold. Strauss completes the operation by splitting a flap from the inner portion of

the hypertrophied muscle fibres. The flap hinges along one edge of the incision, and is turned over the exposed mucosa and fastened with a few interrupted sutures of fine silk to the opposite edge. This covers the mucosa completely. The free end of the omentum is brought over the flap and sutured in position. A cross section of the completed operation shows a lumen well established with the mucosa distended and at the same time protected in its anterior portion by the flap which has been cut from the hypertrophied muscle. The method of completely mobilizing the mucosa without the danger either of perforation of the duodenal mucosa or of leaving a few obstructing fibres, presents certain advantages over the Rammstedt operation.

The Choice of Method. In our own practice we invariably practise the Rammstedt technic. The stomach is thoroughly washed out one hour before operation. Gas and oxygen anæsthesia is employed, and fluid is administered subcutaneously both before and during the operation. We have found it an advantage to ensure a complete hæmostasis by the injection of a few minims of adrenalin chloride solution (1 in 1,000) into the cut surface of the pyloric incision before returning the stomach to the abdomen.

POST-OPERATIVE TREATMENT. Both during and after the operation the child must be kept warm; there is a tendency for a considerable degree of shock to develop, and the maintenance of heat is one of the best methods of its prevention.

Within one hour after operation the child is given $\frac{1}{2}$ ounce of sterile water containing 5 per cent. of glucose, and this is repeated every hour. At the end of twelve hours, citrated milk diluted with equal parts of warm sterile water is given in quantities of $\frac{1}{2}$ ounce every hour, and this quantity is gradually increased to 1 ounce each hour. If the child is on the breast it should be restored to it after twenty-four hours.

FOREIGN BODIES IN THE STOMACH AND DUODENUM

The habit which many children have of placing small objects in their mouths is responsible for the frequency with which such objects as buttons, pins, and small toys find their way into the stomach. If these objects remain within the stomach, or if they are of such a nature that perforation of the viscus wall may result, their removal by operation is required.

Coins larger than a halfpenny will not pass through the pylorus, and it becomes necessary to expose and incise the stomach wall in order to remove them. Pins are peculiarly dangerous; they generally pass through the pylorus, but they become arrested where the duodenum passes across the vertebral column. In this situation they easily perforate the thin-walled bowel, so that a peritonitis results. In this event it is often feasible to manipulate the object so that it

passes back into the stomach, from which it is removed Incision of the duodenum is to be avoided if possible

The use of X rays in the recognition and localization of the foreign body should always be invoked

THE INTESTINES

APPENDICITIS

Appendicitis is the most frequent surgical abdominal ailment of the child, and, as its dangers are now sufficiently recognized, there is no need to dwell upon the importance of the disease Its literature is probably larger than that of any other individual subject, many volumes would be required to contain it, but for our present purpose it is only necessary to allude to the essential aspects of the disease, especially to those which concern the child

ANATOMY

During the first two years of life the amount of lymphoid tissue in the appendix wall is comparatively small, but after the second year the lymphoid tissue begins to grow and to extend until it reaches the maximum of its development about the twentieth year This anatomical detail has a possible influence upon the age incidence of appendicitis, and the connection will presently be alluded to

There is no other point of anatomical interest which characterizes the child's appendix as distinct from the adults

ETIOLOGY

Age Incidence and its Explanation There is a widespread idea that acute appendicitis does not occur during the early months of life, but such a conception is incorrect The truth is that the disease is very rare in the first year of life, it is somewhat less so during the second year, and after this date it becomes progressively more common until about the eighth year, after which it seems to maintain a uniform standard until it reaches the twelfth year, when it may be said to pass out of the sphere of childhood into that of adolescence We have lately analysed the age incidence of the last 500 cases operated on in the Edinburgh Children's Hospital, and the research has elicited the following —

There are at least two points which call for comment apart from the fact of the increasing incidence of the disease as age advances —

- (1) That no period of childhood is entirely free from the disease
- (2) That an explanation is required of the progressively increasing incidence of the disease

We have already alluded to the importance of bearing in mind the first possibility—on four occasions we have met with examples of acute appendicitis in infants who were on the breast when the disease made its appearance, and there is a real possibility of overlooking the true nature of the complaint in the presence of such unusual circumstances.

The second point is difficult to elaborate with any degree of certainty, because an answer to it presupposes a knowledge of the exact etiology of the disease, a point upon which considerable dubiety still exists, but the explanation of the age incidence of childhood may be

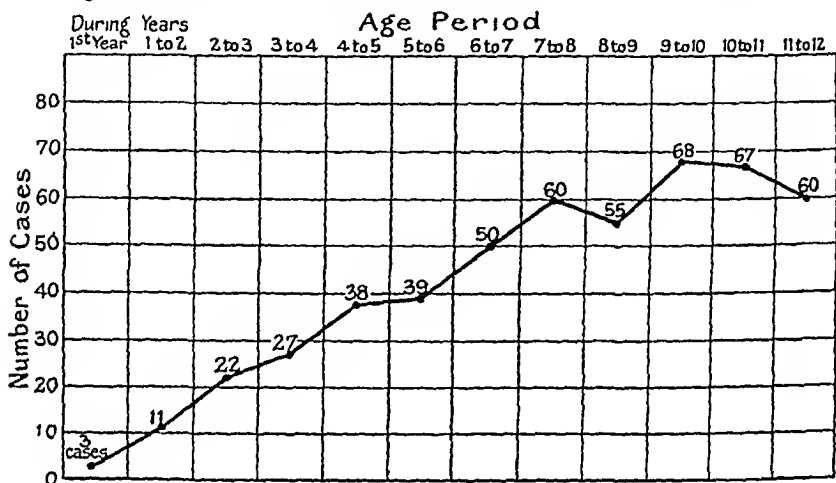


Table illustrating the Age Incidence of Appendicitis in Children.

found in one or more of several possible directions. It is probably affected—

- (1) By the relative amount of lymphoid tissue present in the appendix at different periods of life. This point has been alluded to in connection with the question of anatomy. The amount is certainly very small at birth, and there is comparatively little during the first year. It is generally accepted that the greater the amount of lymphoid tissue, the higher are the possibilities of infection.
- (2) By the fact that the toxicity of the intestinal flora alters as the child grows older. In the majority of cases the *bacillus coli communis* is the organism responsible for the infection, and it is an organism which displays the most remarkable variation in its virulence. Soon after birth, when intestinal digestion first begins, its virulence is comparatively slight, but as the child grows older, this feature becomes progressively greater, the increase being stimulated by the increasing complexity of the diet, and possibly by incidental attacks of gastro-enteric catarrh.

Structural and bacterial influences are therefore the factors which probably explain the relative age incidences.

Other Etiological Influences The various influences which are said to affect the occurrence of the disease in the adult have relative degrees of influence in the child. The effect of foreign bodies is as great in the child as in the adult, worms (*oxyuris vermicularis*) have frequently been reported, and on more than one occasion we have found them in the interior of an inflamed appendix. Stricture, kinks, and ulcers all play a provocative part, for any factor which has an obstructive effect has to be considered. Influences of terminal blood supply and the gastro-enteric infections which result from carious teeth are equally applicable to both children and adults.

PATHOLOGY

The disease begins as an intra-mural infection—the inflammatory reaction being first apparent in the mucous lining of the appendix. If the infection extends it comes into contact with lymphoid tissue in the sub-mucous coat, and in this structure it extends more widely and rapidly than when confined to the interior. From this layer there is an extension through the muscle wall into the sub-peritoneal and peritoneal tissues.

Infection may extend from the interior as a gradual migration through the peritoneum, as a local perforation at one point, or as an extensive necrosis involving the terminal portion, or even the complete extent of the organ.

While the foregoing brief outline of the pathology is generally applicable, the child's appendix has three peculiarities which may be said to influence its pathology: (1) the large amount of lymphoid tissue in the child's appendix is apt to result in a rapid spread of the infection and early involvement of a wide area, (2) the appendix wall is relatively thin, and therefore the infection soon becomes a peritoneal one, (3) the omentum of the child is imperfectly developed, especially in the early months of life, and its protective influence is therefore less effective. In fact, the outstanding characteristic of acute appendicitis in the child is that it is more likely to be a rapidly spreading and extensive infection than the corresponding disease in the adult.

CLINICAL FEATURES

The History If the child has reached an intelligent age, he or she will give an accurate account of the subjective symptoms which they have experienced, an account which is often more accurate than that obtained from the adult. In younger children the clinician will have to rely upon the history as given by the parents or friends, and a good deal of discrimination may have to be exercised before the essential facts are gathered. But even in the case of very young children two leading questions should be put, and the answers given may afford valuable information. The questions are—'Does it hurt?' and in the event of a positive reply—'Where does it hurt?'

If the answer to the second question is accompanied by a gesture towards the right iliac fossa the information is worth attending to.

The Symptoms. Pain, vomiting, and fever are the symptoms common to the average case of appendicitis. The child complains of abdominal pain, and this at first may be localized to the epigastrium, to the umbilicus, or to the lower half of the abdomen. Within a short period of time there is vomiting upon one or more occasions, and the pain becomes localized to the right iliac fossa. It is now apparent that the child has a considerable amount of general disturbance accompanying the local signs, and, when the temperature is taken, fever is found to be present. Constipation usually accompanies the other features of the disorder.

From such a beginning the disease may follow various possibilities :—

- (1) It may gradually subside until there is a complete disappearance of the morbid features.
- (2) While the more acute symptoms may subside, local inflammatory evidences remain in the shape of abscess formation.
- (3) There may be an extension of both the abdominal and the general features, the evidences of a general peritonitis.

The Importance of Bilious Attacks.

There are many cases in which the interrogation regarding the former history brings out an account of what the parents call 'bilious attacks,'—indefinite accounts of abdominal pain and sickness, during which no suspicions may have been entertained that the appendix is the organ really responsible for their appearance. Further inquiry into these former symptoms may confirm a doubtful diagnosis and explain obscure general symptoms.

Special Symptoms depending upon the Position of the Appendix.

If the appendix lies in its normal situation in the right iliac fossa the usual symptoms are displayed, but it may happen that the appendix lies in situations which bring it into contact with other organs and tissues, and where, if the appendix is inflamed, sympathetic or secondary congestion of these other organs or tissues may produce highly characteristic signs. The point is alluded to more fully later, and here it is only necessary to instance one or two examples. If the appendix lies in the pelvis so that it is in contact with the rectum and bladder it is common to find that painful micturition, retention of urine, diarrhoea, and tenesmus may accompany the more usual signs of the disease, a retro-cæcal appendix may lead to the pain being referred to the loin, and an appendix which is associated with an imperfectly descended cæcum may show diaphragmatic signs which suggest a pulmonary lesion.

The Physical Examination. This may tax all the resources

and tact of the examiner. If the child is old enough to appreciate that the clinician is his friend, and that there is no deliberate attempt to hurt him, there will be no difficulty, but in young children, and especially in that type which is known as the 'spoiled child,' there may be such continual resistance that it is very difficult to acquire facts of real value. In such an event we always practise the manoeuvre of giving the child a whiff of chloroform, probably mixed with some pleasant scent, such as eau de Cologne. The child becomes sleepy, no real anaesthesia is induced, but the struggling ceases, and yet the essential evidences of tenderness and muscular rigidity, if present, are easily demonstrable.

The physical examination will commence with a general survey of the child. The facies of general peritonitis is as distinctive in the child as in the adult, in less severe degrees of the disease the child may look poisoned and ill, sometimes he lies on his back with the knees drawn up, he may lie on one side with the knees bent, he is restless and irritable, with a strong objection to being disturbed. The pulse and respiration rates are noted, and the temperature is taken—the temperature is raised, but not excessively, the pulse rate is increased. The tongue is inspected if the patient is agreeable, but, if he objects, it is unnecessary to press the point.

The abdomen is the principal centre of the local examination, and inspection, palpation, and rectal examination are employed.

Inspection reveals —

- (1) The boarding of muscular fixation, and this evidence is local or general according to the extent of the inflammatory change.
- (2) The local swelling of an abscess or the general distention which follows intestinal paralysis or general peritonitis.
- (3) An unusual prominence of the lower abdominal veins. In the presence of any acute low abdominal infection in young children this sign is often well marked.

Palpation is used with extreme care, because the child is resentful of any attempt to handle a sensitive and painful part. Palpation should attempt to supply information regarding the skin, the musculature, and the abdominal contents. The skin may demonstrate the viscerosensory reflex as described by Head and Mackenzie, and in this connection there is the important fact, that as long as the infection is limited to the appendix without involving the peritoneum, the area of cutaneous hypersensitivity is in the region of the groin, but when the peritoneum becomes involved, the region of the right iliac fossa is the area affected. The musculature is examined by light palpation to demonstrate the presence or the absence of the reflex muscular fixation which betokens an underlying inflammatory lesion. The extent of the fixation will depend upon the distribution of the infection, and the demonstration of this rigidity in the region of the right iliac fossa, or wherever the appendix may lie, is almost

invariably demonstrable in acute appendicitis; exceptions to this rule are given later.

Palpation is now carried a little deeper, and for that reason a slightly greater degree of pressure is used, but extreme gentleness must always be practised. The intention is to demonstrate the presence, position, and distribution of tenderness. In acute appendicitis the tenderness is usually very distinct, and once this sign has been elicited and its distribution realized there is no need to repeat the process.

Slight local pressure over the position of the appendix may give rise to a referred pain in the region of the pylorus, but this sign is difficult to bring out with certainty in a young child. A more important sign which may be demonstrated at this stage is the local tenderness which arises in the right iliac fossa if pressure is exerted in an upward direction over the left iliac region; by this movement, gas in the bowel is displaced backwards, and slightly increasing the intra-cæcal pressure, pain is complained of in the right iliac fossa.

It is during this stage of the examination that any swelling which may be present is detected. The rounded outline of an appendix abscess may be felt, but, if there is any difficulty in bringing out this point, it is unwise to continue the palpation.

Percussion is rarely of much value. In an ordinary case of acute appendicitis it may be possible to demonstrate some degree of dullness in the right iliac region, which is said to be produced by the presence of an unusual accumulation of omentum in this area. In retro-cæcal appendicitis the cæcum and ascending colon are often distended in front of the infected focus, and they may afford a tympanitic note in the right iliac fossa.

In the general peritonitis following acute appendicitis it may be possible to elicit a dull note in both flanks suggestive of the presence of fluid.

Rectal examination is a most valuable means of obtaining information regarding the state of affairs within the lower abdomen. If the child is peculiarly sensitive a very light anæsthesia will facilitate the examination without vitiating the results. The rectal examination should be of a bi-manual nature, and in a young child it is possible to explore the pelvis and the lower abdomen by this method more accurately than by a purely abdominal examination. In an ordinary acute appendicitis pressure on the right wall of the rectum induces marked tenderness; if an abscess is present, and especially if the abscess is passing into the pelvis, its demonstration may be very exact. In the presence of a general infection of the peritoneum, œdema, boggiess, and generalized tenderness are manifest.

A SUMMARY OF THE CLINICAL EVIDENCES

In a characteristic case the clinical history may be summarized somewhat as follows: the child complains of abdominal pain which is general, umbilical, hypogastric, or epigastric in position. After a

short time there is vomiting, and the pain tends to be localized to the right iliac region. Signs of a general disturbance now appear, there is malaise with fever, and the child appears toxic and ill, the bowels are constipated. On abdominal examination the lower abdomen is rigid, and the breathing is of the costal and upper abdominal type, there may be increased prominence of the superficial lower abdominal veins on the affected side. On palpation hyperæsthesia is demonstrable over the inguinal ligament if the infection is an intramural one, and over the right iliac fossa if the infection has extended to the peritoneum, there is muscular rigidity over the right lower half of the abdomen, and tenderness is elicited in the right iliac fossa when gentle pressure is exerted, the extent of the tenderness depending on the distribution of the infection. Rectal examination demonstrates local tenderness in the right rectal wall with possibly some œdema of the surrounding parts.

SPECIAL FEATURES DEPENDENT ON LOCALITY

In a certain proportion of cases the position of the appendix does not conform to the majority type, and an unusual site may result in unusual clinical features. The student will do well to bear in mind that there are at least five unusual situations in which the appendix may lie—the pelvic appendix, the retro cæcal appendix, the mesenteric appendix, the sub hepatic or high appendix, and the left iliac appendix. It is necessary to refer to certain features which distinguish the several types.

The Pelvic Appendix Many mistakes are made in the recognition of this type of the disease, because the appendix lies so low that it is really a pelvic organ. Pelvic appendicitis is characterized by the following points —

- (1) The pain and tenderness may be referred to the supra pubic region
- (2) The proximity of the appendix to the bladder and rectum may induce the special signs of painful and frequent micturition, and diarrhoea with or without tenesmus
- (3) The close relationship of the pelvic appendix to the obturator internus muscle may produce an œdema of the muscle, with the result that there is pain on stretching or on contraction of the muscle when rotatory movements of the leg are carried out
- (4) There is a greater tendency to abdominal distention in this type of the disease than in the ordinary variety of appendicitis, because the terminal segments of both large and small intestine (pelvic colon and lower loop of ileum) are involved in the inflammatory reaction

It is unlikely that an error in the recognition of pelvic appendicitis will occur if a rectal examination is made.

The Retro-cæcal Appendix When the appendix occupies a

retro-cæcal position. it lies in contact with the posterior abdominal wall, and in many cases may be partially extra-peritoneal. It is not surprising, therefore, that distinctive symptoms may characterize retro-cæcal appendicitis.

- (1) The pain, tenderness and rigidity may be referred to the loin. This distinction is well appreciated if the loin be gently grasped between the fingers and the thumb, when it will be found that the tenderness and the related muscular fixation prevent the fingers from sinking into the loin.
- (2) Vomiting may not occur in this variety of the disease, probably because the peritoneum is not so early or so definitely affected.
- (3) The relationship of the appendix to the ilio-psoas muscle may result in an œdema and tenderness of the muscle, and this effect is made manifest by a persistent flexion of the right hip, while pain is produced if an attempt is made to induce extension.

The Mesenteric Appendix. It may happen that the appendix lies in close relationship to the terminal portion of the ileum; it may pass superficial to, or deeper than, the bowel, and it may acquire attachment to the upper or the under surface of the mesentery: in any of these cases it may be described as a *mesenteric appendix*.

If an appendix in such a position becomes inflamed, it has a tendency to exert an obstructive influence upon the small intestine, so that signs of an acute intestinal obstruction appear. Vomiting occurs early, is most persistent, and the picture of an intestinal obstruction is completed by the absence of the passage of flatus or fæces from the lower bowel. This type of appendicitis is peculiarly dangerous in childhood.

The Sub-hepatic or High Appendix. We have described how an error in the third stage of rotation of the intestine may result in an imperfect descent of the cæcum, so that it lies in a sub-hepatic or pyloric situation. The high situation of the appendix in the presence of inflammation of that organ is a source of confusion in the correct recognition of the disease. The features which distinguish this variety are .—

1. The local evidences are in the sub-costal region.
2. Vomiting is a persistent symptom.
3. The proximity of the infection to the sub-phrenic region may result in respiratory signs which simulate a diaphragmatic pleurisy or a pneumonia—the respiration rate is quickened, and moist rales may be detected in the lung.
4. Jaundice is a frequent accompaniment.

The left Iliac Appendix. A late rotation error may result in the cæcum occupying the left iliac fossa, and this, of course, apart from any transposition of viscera. In such an event the ordinary evidences

of the disease are transposed from the right iliac fossa to the left, and, as an additional symptom, diarrhœa frequently occurs

THE DIAGNOSIS

In the average case of the disease the signs are so distinctive that the affection is at once recognized. In the history, importance is attached to the order in which the signs and symptoms make their appearance—pain, vomiting, tenderness and fever, any obvious digression from this order should arouse suspicion. The demonstration of local rigidity with tenderness and the evidence which is obtained by a rectal examination are the most reliable physical changes. An estimation of the white cell count of the blood may afford valuable information, for the presence of a leucocytosis may be the determining factor in an otherwise doubtful diagnosis.

Differential Diagnosis In many cases, however, doubt will arise because there are a number of conditions which simulate appendicitis, and these possible pitfalls are even more numerous in childhood than in adult life. It is unnecessary to allude to all the possible sources of error, as many of them are characteristic of the adult, and therefore we shall content ourselves with noticing the more likely possibilities of confusion during childhood.

(a) **Acute Pyelitis** A female child is taken ill with indefinite abdominal pain, high temperature, rigors, vomiting, and constipation with considerable general disturbance. The child is apparently very ill, and it is a characteristic feature of the disease that there is great mental irritability which makes examination difficult. Abdominal examination reveals local tenderness with a minor degree of muscular rigidity. The picture in some respects resembles appendicitis, but actually it is that of acute pyelitis.

The main safeguard against error is the examination of the urine, and such an examination should be a routine in every abdominal illness. It is possible that the need for such an examination is demanded by dysuria and frequency of micturition, but in many cases these regional signs are absent. The urine is acid and opalescent, a deposit is slow to form, at times it is present but slight in amount, and, if a microscopical examination is made of a drop from the middle of the specimen (not from the deposit) pus cells and colon bacilli are found to be present.

Apart from the characteristic condition of the urine, other points characterize the disease—the female sex, the high temperature, the apparent general illness in the absence of severe local signs, the situation of the abdominal tenderness over the pelvis of the kidney, and the slight increase of muscular rigidity which accompanies the tenderness. Special attention should be paid to the fact that the sequence of the symptoms and signs differs from that followed in appendicitis.

Two details should be kept in mind lest they mislead the examiner

—the symptoms may be in existence for some days before pus appears in the urine, and in a long-standing case pus may disappear from the urine because the ureter has become blocked.

(b) **Cyclic Vomiting.** This condition is a frequent source of error, and if a mistake occurs it is particularly unfortunate because operative interference and the administration of an anæsthetic may be extremely detrimental—they may be, in fact, the deciding factors in a fatal termination.

A child becomes pale, irritable, and tired-looking, and complains of indefinite pain, which is often localized to the pit of the stomach; there has been a preceding period of constipation and flatulence. Then, and often with extreme suddenness, vomiting appears, and it is most distressing in its frequency and severity. The error in diagnosis is most likely to occur if the child is first seen during the height of the attack. The child looks drowsy and ill, the abdomen is retracted, and from the persistent retching and vomiting it may be tender and even slightly rigid to the touch. It is then that the error may arise. A history of similar attacks should put the examiner on his guard. There is an absence of localizing abdominal signs, the breath shows the characteristic odour of acetone, the appearance of the child suggests intense illness without any definite explanation, the urine shows the presence of acetone, together with casts and small quantities of albumen and blood.

(c) **Ileo-cæcal Lymphadenitis.** Under certain conditions tuberculosis of the ileo-cæcal glands may closely simulate acute appendicitis. The sequence appears to be that the glands become tuberculous, and, as a result, the bacteria-resisting properties are diminished, so that from time to time there are attacks of sub-acute lymphadenitis, which no doubt arise from an intestinal absorption with which the diseased gland is incapable of dealing. The pathological process is comparatively common in children and the characteristic points in the history are as follows. There is frequently a preceding attack of diarrhoea or intestinal disturbance, the significance of which may be important, because the resulting alteration of the intestinal flora is possibly the exciting feature in the process. Abdominal pain appears—there may be vomiting, though such is by no means constant and there is considerable general disturbance and fever. The symptoms rarely last for more than twenty-four to forty-eight hours, and then abate with characteristic suddenness. It is often exceedingly difficult, sometimes impossible, to distinguish such a case from one of appendicitis, though there are one or two features which may be suggestive.

In lymphadenitis the pain is local from the commencement, never referred: this is a point, however, which it may be impossible to verify in young children. The tongue usually remains clean; the attack subsides with characteristic rapidity; fever introduces the illness, while in appendicitis it is comparatively late in appearing.

It may be possible to palpate the enlarged tender glands. After all is said, however, the fact remains that these points are difficult to verify, and the diagnosis in the great majority of cases will be made after operation for what was considered to be acute appendicitis. In view of the danger in children of the 'wait and see' policy, it is better that this should be so.

(d) Basal Pleuro-pneumonia and Diaphragmatic Pleurisy

If an inflamed appendix occupies an abnormally high position, difficulty may arise in distinguishing this variety from the acute pulmonary conditions which involve the base of the lung and the upper surface of the diaphragm.

There are the commonly quoted distinguishing points, that in pleuro pneumonic conditions the initial fever is high (103° to 105°), the respiration pulse ratio is increased, the *alae nasi* are working vigorously. But distinct from these, and apart from peculiarities of onset and history, there are two tests which are of considerable value in doubtful cases. The first is that of '*opposite side palpation*'. The hand is pressed firmly into the left side of the abdomen. If the origin of the pain is abdominal, an accentuation is referred to the site of the infection, if, on the other hand, the pain is thoracic, no alteration is produced by the left sided pressure.

The second test, though of great value, may be difficult to demonstrate in young children. It is sometimes called the '*collar test*,' and it has a developmental basis. The diaphragm develops in the region of the fourth cervical segment, its musculature is derived from this segment, and its nerve supply (the phrenic) is also derived from the segmental nerve (the fourth cervical). In later development the growth of the thoracic contents displaces the muscle caudalwards, so that it ultimately takes up its position at the thoracic abdominal junction. Its connection with the higher segment, however, is extremely valuable from the diagnostic point of view, for any irritation of the diaphragm is referred along the distribution of the fourth cervical nerve, and an area of hypersensitivity can be marked out which is roughly of a collar shape, hence the name given to the sign. In high appendicular infections the collar sign is absent, while in pleuro pneumonic conditions it is present, though its demonstration in children may be difficult. It is well to remember that, if the high appendicular infection extends to such a degree as to involve the diaphragm, the collar sign will become positive.

The Value of Sgambatti's Test in the Diagnosis of Acute Peritonitis
Sgambatti has described a test which he believes to be of value in the recognition of cases of acute septic peritonitis. The technique is briefly as follows. 2 to 3 c.c. of concentrated nitric acid are added to 8 or 10 c.c. of urine so that a contact zone forms without mixing. Under normal conditions, a reddish brown fringe appears at the zone of contact but if peritonitis exists a bluish grey area develops

¹ Sgambatti *O Policlinico* (Sezprat) 27. 67 (March 1 1920)

—the symptoms may be in existence for some days before pus appears in the urine, and in a long-standing case pus may disappear from the urine because the ureter has become blocked.

(b) **Cyclic Vomiting.** This condition is a frequent source of error, and if a mistake occurs it is particularly unfortunate because operative interference and the administration of an anaesthetic may be extremely detrimental—they may be, in fact, the deciding factors in a fatal termination.

A child becomes pale, irritable, and tired-looking, and complains of indefinite pain, which is often localized to the pit of the stomach; there has been a preceding period of constipation and flatulence. Then, and often with extreme suddenness, vomiting appears, and it is most distressing in its frequency and severity. The error in diagnosis is most likely to occur if the child is first seen during the height of the attack. The child looks drowsy and ill, the abdomen is retracted, and from the persistent retching and vomiting it may be tender and even slightly rigid to the touch. It is then that the error may arise. A history of similar attacks should put the examiner on his guard. There is an absence of localizing abdominal signs, the breath shows the characteristic odour of acetone, the appearance of the child suggests intense illness without any definite explanation, the urine shows the presence of acetone, together with casts and small quantities of albumen and blood.

(c) **Ileo-cæcal Lymphadenitis.** Under certain conditions tuberculosis of the ileo-cæcal glands may closely simulate acute appendicitis. The sequence appears to be that the glands become tuberculous, and, as a result, the bacteria-resisting properties are diminished, so that from time to time there are attacks of sub-acute lymphadenitis, which no doubt arise from an intestinal absorption with which the diseased gland is incapable of dealing. The pathological process is comparatively common in children and the characteristic points in the history are as follows. There is frequently a preceding attack of diarrhoea or intestinal disturbance, the significance of which may be important, because the resulting alteration of the intestinal flora is possibly the exciting feature in the process. Abdominal pain appears—there may be vomiting, though such is by no means constant and there is considerable general disturbance and fever. The symptoms rarely last for more than twenty-four to forty-eight hours, and then abate with characteristic suddenness. It is often exceedingly difficult, sometimes impossible, to distinguish such a case from one of appendicitis, though there are one or two features which may be suggestive.

In lymphadenitis the pain is local from the commencement, never referred: this is a point, however, which it may be impossible to verify in young children. The tongue usually remains clean; the attack subsides with characteristic rapidity; fever introduces the illness, while in appendicitis it is comparatively late in appearing.

It may be possible to palpate the enlarged tender glands. After all is said, however, the fact remains that these points are difficult to verify, and the diagnosis in the great majority of cases will be made after operation for what was considered to be acute appendicitis. In view of the danger in children of the 'wait and see' policy, it is better that this should be so.

(d) **Basal Pleuro-pneumonia and Diaphragmatic Pleurisy**
If an inflamed appendix occupies an abnormally high position, difficulty may arise in distinguishing this variety from the acute pulmonary conditions which involve the base of the lung and the upper surface of the diaphragm.

There are the commonly quoted distinguishing points, that in pleuro pneumonic conditions the initial fever is high (103° to 105°), the respiration pulse ratio is increased, the *alæ nasi* are working vigorously. But distinct from these, and apart from peculiarities of onset and history, there are two tests which are of considerable value in doubtful cases. The first is that of 'opposite side palpation'. The hand is pressed firmly into the left side of the abdomen. If the origin of the pain is abdominal, an accentuation is referred to the site of the infection, if, on the other hand, the pain is thoracic, no alteration is produced by the left sided pressure.

The second test, though of great value, may be difficult to demonstrate in young children. It is sometimes called the 'collar test,' and it has a developmental basis. The diaphragm develops in the region of the fourth cervical segment, its musculature is derived from this segment, and its nerve supply (the phrenic) is also derived from the segmental nerve (the fourth cervical). In later development the growth of the thoracic contents displaces the muscle caudalwards, so that it ultimately takes up its position at the thoracic abdominal junction. Its connection with the higher segment, however, is extremely valuable from the diagnostic point of view, for any irritation of the diaphragm is referred along the distribution of the fourth cervical nerve, and an area of hypersensitivity can be marked out which is roughly of a collar shape, hence the name given to the sign. In high appendicular infections the collar sign is absent, while in pleuro pneumonic conditions it is present, though its demonstration in children may be difficult. It is well to remember that, if the high appendicular infection extends to such a degree as to involve the diaphragm, the collar sign will become positive.

The Value of Scambatti's¹ Test in the Diagnosis of Acute Peritonitis
Scambatti has described a test which he believes to be of value in the recognition of cases of acute septic peritonitis. The technique is briefly as follows. 2 to 3 cc of concentrated nitric acid are added to 8 or 10 cc of urine, so that a contact zone forms without mixing. Under normal conditions, a reddish brown fringe appears at the zone of contact, but if peritonitis exists a bluish grey area develops

¹ Scambatti *O Urologico* (Serprat) 27. 267 (March 1 1920)

above the red zone. If the specimen is allowed to stand for some time the blue-grey colour diffuses itself throughout the urine, and by the addition of chloroform a ruby-red tint develops. According to Sgambatti, the colour change depends upon the appearance of oxidation products which are pathognomonic of peritonitis; the intensity of the reaction is supposed to vary with the acuteness and gravity of the infection. The specificity and the value of the test are still *sub judice*.

THE PROGNOSIS

It is difficult to give an inclusive estimation of the prognosis—there are so many factors which influence the individual case. In general the tendency to rapid spread and early perforation of the organ increase the gravity of the disease, and of individual factors the following are of importance:—

- (1) The age of the child.
- (2) The position which the appendix occupies.
- (3) The type of the infection.

(1) *The Age of the Child.* We believe it to be a correct observation that the younger the child the more serious is the prognosis. This is not on account of the greater acuteness of the infection in early life, for, as a matter of fact, the lesser degree of lymphoid tissue in infancy tends to delay the spread of the disease; rather is it because young children tolerate a septic infection particularly badly. During the first four years of life the mortality rate is at its highest.

(2) *The Position of the Appendix.* The influence of this factor is considerable. The retro-cæcal appendix is a peculiarly dangerous type, because of its relationship to the cellular tissue of the posterior abdominal wall. The high appendix comes next in seriousness; its situation makes operative access difficult, there is a heavy degree of absorption from such a high abdominal level, and, if the inflammatory infection spreads to any extent, pulmonary complications are peculiarly liable to ensue. The mesenteric appendix has the special aspect of danger that it may result in an acute small intestine obstruction. The pelvic appendix is the type which is most often missed in its early recognition, and in this respect its prognosis is affected, but this variety is responsive to treatment, and even in the presence of an advanced infection the mortality is small.

(3) *The Type of Infection.* A streptococcal infection is the most unfavourable organismal type. There is a tendency to a progressive spread of the inflammation because the omentum does not exert its full effect in the presence of this organism, and though at first the child responds well and seems to improve after operative treatment, relapses are common, and secondary abscess formation is a frequent event.

Under this heading the influence of the actual pathology may be

considered. The intra mural lesion is naturally the most favourable, and the greater the extent of the infection the more serious does the outlook become. The highest mortality of the disease is recorded in cases of general peritonitis.

TREATMENT

When it is recognized that the child is suffering from appendicitis, operation offers the most satisfactory and the safest form of treatment. If the infection is an acute one, the sooner the operation is undertaken, the better are the prospects of the child's recovery, if the infection is a chronic one, or if it is first seen by the surgeon when the acute symptoms have subsided, operation should be arranged for the earliest convenient opportunity, when acute symptoms are absent.

Treatment when Operation is impossible. If by force of circumstances, operation is impracticable, a line of careful conservative treatment is pursued. The child must be kept at complete rest in bed, local heat is applied to the abdomen, and, as the greatest amount of comfort is obtained by dry heat, a light electric pad or a small hot-water bottle is used. Any sense of weight should be avoided, as this increases the discomfort. The child is kept upon a liquid diet—at first water or diluted milk, and afterwards clear soup. A small soap and water enema may be given, and the escape of flatus which follows often gives great relief, on no account should any purgative medicine be administered by the mouth. Rectal saline should be given by the 'drip' method, or in amounts of 2 to 3 ounces at a time. If the diagnosis has been definitely made, immediate relief from pain should be assured by a small injection of morphia. The child is nursed in a sitting up position, as the infection may be thereby confined to the pelvis. If the sickness is excessive, relief may be obtained by washing out the stomach.

Operative Treatment

The operative treatment varies under three different conditions —

- 1 In simple appendicitis
- 2 In appendicitis complicated with abscess formation
- 3 In appendicitis complicated with general peritonitis

(1) **The Operation in simple Appendicitis.** The technique of this operation is now so well known that a detailed description is scarcely necessary. A gridiron incision is the most favourable route of access. The caecum is recognized, and, when it is gently brought out of the wound, the appendix becomes visible, difficulty is only experienced if the appendix lies in the retro caecal position, or if the caecum is misplaced.

The appendix mesentery is ligatured *en masse* by passing a ligature through the mesentery close to the caecum. The mesentery is then divided close to the appendix so as to minimize the risk of a slipped

ligature. A purse-string catgut suture is passed through the cæcal wall at some little distance from the appendix base, the appendix is clamped close to the cæcum, a ligature is tied in the groove, the appendix is removed by division immediately distal to the ligature, and the stump, having been touched with pure carbolic, is invaginated into the cæcum by tying the purse-string suture. It is advisable to make matters more secure by inserting a second suture over the original purse-string. In closing the abdominal wound it is unnecessary in the child to attempt to suture the peritoneum separately; it is better to unite peritoneum, transversalis and internal oblique as a single layer, and to suture them in the line of the original cleavage with interrupted catgut sutures. The external oblique is closed with a continuous catgut suture.

(2) **Operation in the Presence of an Abscess.** The distinctive technique in this event is important. The abdomen is opened in McBurney's line. It is sometimes stated that the deeper muscles should be divided in the line of the skin incision rather than split, because of the greater drainage facility thus afforded, but it is doubtful whether this is necessary. The peritoneum is exposed, and great care is exercised in opening it, because the surgeon is anxious to gain entrance to the peritoneal cavity without disturbing the abscess. Entrance having been gained, the abscess is isolated by inserting a series of packs—one is placed in the right kidney pouch, a second passes into the mid-line and protects the small intestine, while a third is inserted along the brim of the pelvis, and prevents a spread of the infection downwards.

These precautions having been taken, the abscess is gently penetrated with the gloved finger from the outer side of the cæcum. The pus which escapes is mopped up as fast as possible until the abscess is dry. The interior is now inspected; if the appendix is apparent, and its removal can be accomplished without much disturbance, it is removed, but, if it is invisible, it is unwise to search for it, as valuable restricting barriers may be destroyed.

Drainage is established by one or more pieces of dental rubber drain, the packs are removed, and the peritoneum, musculature, and skin are closed in such a way as to allow sufficient space for drainage.

In most cases the presence of the abscess means that the appendix has been virtually destroyed, but, if there is reason to believe that it is still intact, its removal is carried out at a later date, when the inflammatory reaction has subsided.

(3) **Operation in the Presence of general Peritonitis.** In a case of this description efficient drainage is the ideal which is aimed at. Gas and oxygen anæsthesia is used. The abdomen is opened in McBurney's line by the usual 'splitting' method, and the appendix is isolated and removed. While the operator's hand is in the abdomen, the secondary incisions are made, and it is an advantage to use a

thimble for this purpose—it facilitates the incision and it protects the operator. The principal secondary incision is a supra pubic one to drain the pouch of Douglas, it is best made in a transverse axis about 1 inch above the upper border of the pubis. Through this incision a glass tube passes into the pouch of Douglas. If the abdomen contains a large amount of pus, a second incision is made in the left iliac fossa internal to the anterior superior spine, and into this opening a soft rubber drain is passed. Through the original wound, two drains are now inserted—one passing downwards into the pelvis, and the other passing upwards into the kidney pouch. The wounds are now closed as far as may be necessary, and the drains are fastened in place with sutures.

The 'Closed' Method of Treatment During the past few years there has been a tendency to treat the diffuse type of peritonitis without intra peritoneal drainage. The appendix is exposed and removed through a right para median incision, the various pouches of the abdomen are mopped dry with gauze sponges, and the peritoneum is thereafter closed. A soft rubber drain is passed down to the extra peritoneal tissues, and the outer layers are sutured. The principle underlying this method is really a reliance upon the strong natural anti bacterial power of the peritoneum, the resistance of which is interfered with if drainage material is introduced.

THE AFTER-TREATMENT

Uncomplicated Cases After a simple appendectomy the post-operative course is usually devoid of any complication or real anxiety. Within forty eight hours flatulence may become troublesome, and it is relieved by a small flatus enema. It is our practice to give the post-operative dose on the fourth morning. The child remains in bed for twelve days.

Abscess Cases If an abscess is present, the post operative treatment is similar to that followed in the simple case, with one or two distinctions. the dressing should be changed twice daily, a drain should never be removed completely and then re inserted, for, unless an anæsthetic is used, the child is greatly alarmed at the attempt at re insertion. It is very much better to loosen the drain from day to day, removing a small piece each day until the amount in the wound is so short that its presence can be dispensed with. If proper drainage is established, dry dressings are more comfortable than fomentations.

Peritonitis Cases The after treatment in this class of case is of great importance, for upon it a successful result may often depend. The following account embodies the details which we invariably follow, and which we have found successful.

As soon as the operation is completed, thick hot fomentations are applied over the complete anterior abdominal surface. In order that the heat may be retained these are made of double layers of gamgeo tissue, and, as the essential principle is that the abdominal surface be

kept at a consistently high temperature, frequent changing is necessary. Fomentation treatment is continued for four days. The child is nursed in a sitting position, he is encouraged to drink plenty of fluid, and rectal salines are given. If pain is complained of, small doses of morphia are given. Flatulence is relieved by enemata, and a purgative is given on the fourth day. If there is much sickness after operation the stomach should be washed out with an alkaline fluid. As in the case of an abscess, drains are not removed and re-inserted, but are shortened gradually from day to day. Glass drains are emptied by a syringe and catheter, they are frequently rotated to prevent strangulation of omentum, and they should be removed about the third day, when a soft rubber drain is substituted.

Post-operative Complications. Secondary abscess formation, faecal fistulae, and acute intestinal obstruction are the post-operative complications most frequently encountered, and it is only in suppuration cases that they occur.

Secondary abscess formation is generally in the pelvis; suspicions are aroused if the temperature begins to swing, if supra-pubic pain is complained of, if there is pain on micturition and diarrhoea, and if it is noticed that the abdomen is gradually becoming distended. Rectal examination reveals the boggy, tender outline of an abscess.

The abscess is opened by passing the finger into the pelvis from the original wound, or by making a supra-pubic incision.

Faecal fistulae sometimes complicate the progress of an appendix abscess. The condition is best left alone—purgative medicines are avoided, and the bowel is emptied by enemata. In the large majority of cases the fistula closes spontaneously; in a very few cases it may be necessary to close it by operative measures.

Acute Intestinal Obstruction. This complication arises under two conditions :—

- (1) A single loop of small intestine may become obstructed during the resolution stages following upon an acute appendicitis, or one associated with abscess formation.
- (2) A generalized small intestine obstruction, paralytic in its nature, may follow an acute peritonitis.

(1) *The Localized Obstruction* In this event the operator usually finds that a loop of small intestine has become adherent to the floor of the pelvis, and has kinked in this position so that an obstruction develops. The complication calls for the reopening of the abdomen and relief of the mechanical error.

(2) *The General Obstruction.* The best advice which can be given in this event is to recognize the complication while it is in its early stages, and to deal with it before the destruction of the gut has become extreme.

A molasses enema should be administered and followed twenty minutes later by $\frac{1}{2}$ c.c. of pituitary, injected intra-muscularly. If this

fails to relieve, and the distention continues to increase, one or more catheters should be inserted into the most distended loop of bowel. Vomiting is meantime relieved by gastric lavage, and the lower bowel is emptied by enemata.

The most recent advance in the treatment of the extreme degree of obstruction is the method of *lymphaticostomy*, by which drainage of the thoracic duct is established in order to prevent the absorption of toxic products into the system.

Chronic Appendicitis

We are sometimes apt to imagine that the manifestations of chronic affections of the appendix are confined to adult life, but such is not the case—in many instances the child shows a typical group of symptoms.

There is often a history of an acute attack of appendicitis, though it may be that this illness passed unrecognized. The child has then gradually passed into an unsatisfactory condition of health—he has become pale, sometimes even toxic, he complains of being easily tired, his appetite may diminish, and there is often a gradually increasing constipation, discomfort and occasional pain are complained of in the right iliac fossa, colic may begin to appear, and many children develop a condition of pyloric spasm which produces an epigastric pain, generally coming on in the morning when the stomach is empty. At intervals there may be sharp attacks of vomiting, which are ascribed to biliousness, and during these attacks, tenderness over the appendix may be demonstrated, and acetone is found in the urine.

The picture is actually one of an indefinite yet unsatisfactory condition of health, symptoms and signs are referred to the abdomen, and accompanied by features which suggest that some toxic process is at fault. In a case of this description suspicion should fall on the appendix, and in many cases further investigation will confirm the suspicion.

Appendectomy is the treatment indicated, and the operator will often find that, associated with the infected appendix, there is a mobile cæcum and ascending colon.

INTUSSUSCEPTION

Intussusception, the invagination of one portion of the bowel into another, is one of the commonest causes of acute intestinal obstruction in children, and its recognition and efficient treatment are matters of vital importance.

ÆTIOLOGY

The mechanical process which results in the production of an intussusception is comparatively simple. It would seem that an

irregularity in the conduction of the peristaltic wave is the underlying cause. A ring of contraction develops in a segment of the bowel, for some reason this is not transmitted, and its persistence at one point results in the invagination of the active portion into the lumen of the passive segment lying in continuity with it. The invagination of the advancing bowel results in a stimulation of the receiving portion, and this stage is actually the most critical of the whole process of intussusception, for the contraction of the receiving bowel will have one of two possible effects—it will either expel the invaginating seg-



FIG. 434.—An example of acute Entero-colic Intussusception.

The specimen has been 'windowed' in order to show the relationship of the various parts

ment, in which case the danger has passed with no more symptoms than a passing colic, or, if its contraction has been longer delayed, it will grasp the entering segment, and actually force it along its invaginating course.

While we may imagine the mechanical error to be somewhat on the lines described, there is difficulty in discovering the source of the original local peristalsis. It is probable that several factors are at fault.

1. *Irritation of the mucous membrane has an influence on the pro-*

duction of the error There are several facts which bear this out —

- (a) An error in diet is frequently elicited in the history of the illness
- (b) Intussusception often develops as a sequel to an attack of enteritis and diarrhoea
- (c) Intussusception is commonest among children of the poor, the explanation would seem to be that errors in diet are more likely to occur in children of this type

2 *There is a structural peculiarity of the intestine which predisposes to the disease* The presence of a mesentery to the cæcum and ascending colon is constantly found when ilco cæcal or ilco colic intussusception appears. This developmental error permits the necessary mobility of the bowel, and may possibly have a relationship to the question of nerve supply, of which mention is made later.

Another structural influence is related to the character of the muscular wall of the bowel, for it is in the strong muscular gut of the well nourished baby boy that intussusception appears, while it is correspondingly uncommon in the atonic bowel of the unhealthy and ill nourished child.

3 *It is possible that an error in the arrangement of the splanchnic nervous system may influence the incidence of the disease* Intussusception has a definite age incidence, the large majority of the cases appearing between the sixth month and the second year. A second peculiarity is the tendency which certain cases have to recur even as often as four or five times. Both of these tendencies have been explained by assuming that a predisposition to intussusception occurs owing to the existence of an error in the structure or in the development of the visceral sympathetic system. The researches of Bayliss and Starling have shown that intussusception can be produced experimentally by paralysing Meissner's and Auerbach's plexuses.

4 *There are cases of intussusception in which the inversion of a diverticulum, the presence of a polypus, or of a swollen hypertrophied Peyer's patch is the original stimulating factor of the peristalsis* The influence of the last (Peyer's patch) has frequently been quoted as the origin of enteric intussusception in children.

The various factors which appear to affect the etiology of the condition may be summarized as follows —

- (a) It is a disease of infancy, the most common period being from six months to two years
- (b) The disease generally occurs in well nourished boys
- (c) An irritation of the mucous membrane is often the exciting factor

PATHOLOGY

TERMINOLOGY It has become the practice to apply individual names to the various parts of an intussusception. A single intussusception is composed of three layers from within outwards, *entering*,

returning, and *receiving*. The two inner layers are sometimes grouped together under the term *intussusceptum*, while the outer or receiving layer is known as the *intussusciens*. The tip of the *intussusceptum* is the *apex* of the *intussusciens*, the proximal part of the *intussusciens* is called '*The Neck*,' and the ridge which is formed at this point by the junction of the two outer layers is known as '*Le Bourellet*'

There are many intussusceptions in which a succession of invaginations occurs, and the terms '*double*,' '*triple*,' or even '*quadruple*,' intussusceptions may be applied. The position arises when the *intussusceptum* of the original intussusception ceases to invaginate itself into its own *intussusciens*, but the complete intussusception proceeds to invaginate itself into the bowel beyond. Repetition of this process produces triple or quadruple intussusceptions. An intussusception is *complete* when the circumference of the gut is invaginated; it is said to be *partial* or *lateral* when only a portion of the circumference is drawn as a cone within the ensheathing layer. An intussusception, like a hernia, may be *reducible* or *irreducible*, *strangulated* or *incarcerated*, *inflamed* or *gangrenous*.

From a clinical basis we recognize four different types of intussusception—*enteric*, *ileo-cæcal*, *ileo-colic*, and *colic*.

The *enteric type* is the invagination of small intestine into small intestine, the lower end of the ileum being the common site of occurrence.

An *Ileo-cæcal Intussusception* is really a pathological exaggeration of the slight degree of intussusception which normally exists at the ileo-cæcal valve, and, as the invagination occurs, the reduplication is at the expense of the colon.

The *Ileo-colic Intussusception* is one in which the original intussusception is actually an enteric one in the lower end of the ileum close to the ileo-cæcal valve. The apex formed by the lower end of the ileum passes through the opening of the ileo-cæcal valve, and in a pure ileo-colic intussusception, the invagination is actually occurring at the expense of the ileum. In practice the ileo-colic intussusception is often of a double character, because the pure ileo-colic type is spontaneously arrested by the thick and short mesentery of the ileum, but the invagination continues because the ileo-colic *intussusceptum* now travels onwards *en masse* into the colon, and its advance is at the expense of the ascending colon—an *iliaca-ileo-colic intussusception*.

Colic Intussusception requires no special explanation—colon is invaginated into colon.

Appendicular Intussusception. This very rare form of intussusception has been described by Corner and others; the base of the appendix becomes the apex of an intussusception entering the cæcum.

Ascending or retrograde Intussusception. Intussusceptions are nearly always descending; a small proportion are ascending, and the authenticated cases which have been described have all occurred in

the colon with the exception of an enteric retrograde invagination described by Rigby in 1903

Pathological Changes in an Intussusception Were it not for the presence of the mesentery and the meso colon, the mere invagination of one segment of bowel into another would not be of extreme importance. It is the group of changes which results from pressure on the mesenteries which gives intussusception its serious characters, for the mesentery and the meso colon, when they are drawn in between the entering and returning layers of an intussusception, are subjected to tension and frequently to torsion and strangulation. The progress of events may be traced step by step as revealed in a typical ilco colic intussusception.

The intussusception has not been long in progress before the mesentery of the entering layer forms an axis upon which the returning and ensheathing layers are piled up. The tension on this axis becomes progressively greater, so that the intussusception is curved towards the mesentery. This curvature is greatest in the entering layer, and a deep crease is often produced upon its concave side. The drag of the taut axis upon one lip of the orifice of the intussusception reduces the opening to a vertical slit directed eccentrically against the mesenteric wall of the sheath. But a further and more disastrous influence soon comes into play. The sheath regards the intussusceptum as a foreign body, which is violently stimulating its lining mucosa, and it therefore is constantly endeavouring to establish a ring contraction above it in order to squeeze it along the intestine. The effect of this contraction is exerted upon the entering mesentery, with the result that a group of changes similar to those seen in a strangulated hernia begin to make their appearance in the invaginated bowel to which the prolapsed mesentery passes. The pressure first affects the thin walled veins, and a condition of acute venous congestion ensues. The greater the congestion the larger becomes the bulk of the intussusception, so that eventually the pressure at the intussusception neck is so great that the arterial supply is affected. Changes, therefore, which have begun as an oedema and extravasation of blood may soon pass into necrosis and gangrene. The swelling is most marked at the apex and along the convexity of the intussusception because these parts are free from pressure. The middle layer is, as a rule, more damaged than the central one.

The diminished vitality of the bowel wall which inevitably follows these changes results in an extension of the organismal contents through the wall into the overlying peritoneum, and a progressive peritonitis develops—omentum becomes adherent over the surface, and in a neglected case a local perforation or a widespread gangrene leads to a terminal general peritonitis.

The rapidity with which these changes appear varies in degree, and therefore acute and chronic types of intussusception may be recognized.

The Sequelæ of a neglected Case If operation is not performed the

usual result is gangrene or perforation, with a rapidly fatal peritonitis. In a certain proportion of cases other events may happen :—

- (1) Spontaneous reduction may occur if the intussusception is not too fully established ; or
- (2) Spontaneous elimination of the intussusception may ensue, the gangrenous bowel being passed in small fragments or in complete segments.

Peculiarities of different Types. In a *colic intussusception* irreducibility and strangulation are uncommon because the neck of the intussusceptum is wide, the meso-colon is thin, and the vascularity is not great.

In *Ileo-colic Intussusception* the dangers of strangulation are extreme, because every factor predisposes towards it—the ileo-cæcal valve, through which the bowel is prolapsed, exerts extreme tension, the mesentery of the lower ileum is thick enough to be subject to considerable pressure, while the vascularity of the parts is intense.

SYMPTOMATOLOGY

A baby who has previously been in good health, often a finely developed child and frequently a boy, is suddenly seized with violent intestinal colic. The small sufferer draws up his knees as the attacks come on, and screams lustily ; pain and astonishment are displayed in his face, and in some instances an intense pallor is noticed. Soon after the onset of the pain, the baby may vomit once or twice, but at this stage vomiting is not an urgent feature, and the bowel may move normally.

From a comparatively slight beginning the attacks of pain gradually work up to a climax, when the pain appears to be continuous with intervals of exacerbation. Some degree of tenesmus appears, and a quantity of blood-stained mucus is passed by the bowel. If the condition remains untreated the sufferer becomes quieter and more apathetic, this being the result of the powerful toxæmia, and a child in this condition has a characteristic sunken yet placid appearance, rousing itself to scream faintly if disturbed or when spasms of pain occur. In the later stages of the disease the vomiting may become more constant and persistent.

As the intussusception travels farther downwards, the straining and tenesmus are more noticeable, and the intussusception may actually become protruded from the anus.

After forty-eight hours the abdomen becomes distended, the temperature rises, and the tenderness and rigidity displayed by the abdominal wall are evidences that a terminal peritonitis is developing.

EXAMINATION

General. The general appearance of the child is often characteristic. At the very commencement of the process the deep pallor of

abdominal shock may be apparent, evidences of intense intestinal colic are manifest later, but it is at a still later stage that the really typical facial appearance is to be seen—the sunken collapsed look, with dark rings around the eyes, and an apathetic expression.

Abdominal Abdominal examination should be at once proceeded with, and in most cases an abdominal tumour can be felt. If the resistance of the child makes the investigation difficult there should be no hesitation in administering a light general anæsthetic. The tumour is sausage shaped, about 1 inch in diameter, and of variable length. It hardens and becomes more definite during the spasms of pain, while it may almost disappear in the intervals. It is most frequently found in the left loin, but it may be detected at any point in the colon where it is accessible to palpation. It is most liable to be overlooked when it passes below the liver or into the region of the splenic flexure.

The tumour is tender to touch, and handling of it induces renewed spasms. It is said that emptiness of the right iliac fossa may be made out in the ileo cæcal type of intussusception, but this sign is a very uncertain one.

Rectal The examination will conclude with a rectal examination, and the examiner is anxious for information on three points —

- 1 Is blood stained mucus present in the bowel?
- 2 Is faecal matter present?
- 3 Can a tumour be felt?

The presence of blood stained mucus in the bowel is one of the most characteristic and well recognized features of intussusception. Under certain conditions the sign is absent, as we shall have occasion to remark, but in the vast majority of cases it can be demonstrated. The blood is a bright red colour, and is usually intimately mixed with mucus (red currant jelly). The presence of faeces in the bowel should not be detectable except in the very early stages of the disease, a case in which faecal matter is mixed with blood and mucus is unlikely to be one of intussusception, unless it be of the colic type.

The presence of a tumour is pathognomonic of the disease. It is the apex of the intussusception coming in contact with the finger, which gives the characteristic sensation, but the sign is only demonstrable when the intussusception has reached a low level.

CASES IN WHICH THE SYMPTOMS AND SIGNS SHOW A DEPARTURE FROM THE NORMAL

There are certain cases of intussusception which do not conform to the typical clinical picture, and it is important to appreciate the circumstances under which the distinctions may arise.

- 1 There are cases in which blood does not appear until late in the course of the disease. In enteric intussusception the ileo cæcal valve appears to arrest the onflowing of the blood and this

peculiarity has been responsible for regrettable delay in the recognition and treatment of such cases.

2. Pure colic intussusceptions have definite characteristics. They may persist for as long as six weeks without giving rise to acute intestinal obstruction. The wide bowel lumen with its thin wall and adaptable mesentery may prevent any great danger of strangulation occurring, therefore blood may only appear in small quantity, and faecal matter may be present in considerable amount mixed with the bowel contents.

DIAGNOSIS

A history of severe intestinal colic occurring in a baby and accompanied by the passage of blood-stained mucus from the bowel should at once suggest the possibility of intussusception. The presence of a palpable abdominal tumour will confirm the suspicion, though the inability to feel the tumour does not exclude the possibility. The absence of faecal matter from the blood-stained mucus is extremely suggestive of intussusception.

The differential diagnosis may give rise to difficulty. There are at least three conditions which are liable to be confused with intussusception—acute entero-colitis of babies, Henoch's or abdominal purpura, and prolapse of the rectum.

Acute Entero-colitis and Intussusception. These two conditions have much in common, and the possibility must always be borne in mind of entero-colitis causing intussusception. Both conditions affect babies, both are frequently preceded by such digestive disturbances as diarrhoea and slight vomiting, blood and mucus are passed with tenesmus in both cases. The crucial point in the diagnosis is whether complete intestinal obstruction is present or not. This is ascertained by testing for bile in the blood and mucus on the napkin of the baby. If it is present after the first motion or two, the case is probably one of entero-colitis. The only exception to this rule is found in the comparatively rare chronic colic intussusception.

Another important point is the character of the onset. In acute intussusception this is almost always sudden; in acute colitis it is more gradual, and is led up to by vomiting and diarrhoea.

Henoch's or abdominal Purpura. A boy older than the age at which intussusception usually occurs complains of intestinal colic. There is tenesmus, and blood-stained mucus is passed per rectum. When the abdomen is examined an elongated tumour may be felt in the left iliac fossa, and the mistake has been made of confusing this syndrome with intussusception.

There are points of clear distinction, however. In abdominal purpura the patient is a boy of six or seven years old, there is never a true intestinal obstruction, faecal matter is present in company with the blood and mucus, when the rectum is examined no tumour can be felt, but there is a characteristic oedematous feeling of the rectal

mucosa, and the iliac tumour, which is really an infiltration of the coats of the colon with hæmorrhagi, is fixed in its position. The last feature is perhaps the most distinctive, in the course of the disease, points of ecchymoses make their appearance around the joints of the extremities.

Prolapse of the Rectum An intussusception which is protruding from the anus has been mistaken for a prolapse of the rectum, and therefore it is necessary to allude to such an unlikely error. Apart from the general symptoms, a local distinction can always be made by attempting to insert the fingers between the wall of the rectum and the protruding tumour. In true prolapse there is no interval into which the fingers can be inserted, while in intussusception the examining finger can be swept completely around the prolapse.

PROGNOSIS

Spontaneous Cure Spontaneous cure does not occur in more than 1 or 2 per cent. When it occurs it takes place by spontaneous reduction, by spontaneous elimination of the intussusception, or by a faecal fistula forming above the intussusception and establishing a communication with the surface.

At the present time practically every case is submitted to surgical operation, and the prognosis really depends upon the reducibility or irreducibility of the tumour. The type of intussusception and the duration of the illness are the factors which affect this feature. An ilco eclic intussusception is the most difficult to reduce, and the type which first show gangrenous changes. Enteric intussusception comes next in these respects. The time factor is a very apparent one, for it is obvious that the longer an intussusception has been in existence the more difficult will it be to reduce.

TREATMENT

Under modern conditions, operative treatment is invariably adopted, references to other methods are either of historical interest, or apply to situations of unusual emergency.

CONSERVATIVE TREATMENT A situation may arise under which operation is impossible. In such an event the stomach is washed out, a small enema of warm water is given, and three or four minims of tincture of opium are administered by the mouth.

If general anæsthesia is available, deep anæsthesia is induced, and through the lax abdominal wall an attempt is made to reduce the intussusception. The chances of success are small, and the method is only permissible in the unlikely possibility of operative treatment being unobtainable.

Attempted Reduction by the Injection of Air or Water These methods are practically of historical interest only, though a number of successful cases have been recorded by both methods.

In the air reduction a modification of a bellows was used to inflate the bowel through the rectum ; the danger of the method lay in the inability to regulate the amount of air which was injected.

The injection of water was a more reliable and successful method. Under deep general anæsthesia a stream of warm water flowing from a head of about two feet was directed into the bowel with a long rubber catheter, the child meantime being inverted so as to favour the inflow of the water. The impact and pressure of the fluid upon the tumour, aided to some extent by abdominal manipulation, sometimes succeeded in reducing the obstruction, but only in the early case, and even so, it was impossible to say, until some time had elapsed, that reduction was really complete.

Operative Treatment

As soon as the diagnosis is made, laparatomy should be advised and proceeded with.

Preliminaries. If there has been much sickness the stomach should be washed out, and, if there is evidence of collapse, a subcutaneous saline should be given immediately before or during the operation. Every precaution must be taken to keep the child warm during the operation.

Operation. A middle line or a paramedian incision is generally used. It is our practice to employ a right gridiron incision, and we believe that this method has advantages over the others because the wound is more easily closed, and less operative shock results.

When the abdomen has been opened, the small intestine must not be allowed to prolapse, but the operator's hand is gently introduced and the intussusception located. Whatever its immediate situation may be, it is gradually manipulated *within the abdomen* until it has been brought to the ileo-cæcal region. The tumour is now gently lifted to the surface, and its type is recognized. Colic and enteric varieties present no difficulty ; the distinction between the ileo-cæcal and the ileo-colic types depends upon the relationship of the appendix to the tumour. In an ileo-cæcal intussusception the appendix is engaged in the apex of the intussusceptum ; it therefore disappears at the commencement of the disorder, and only reappears when reduction is complete. In the pure ileo-colic type the appendix remains *in situ*, because the invagination is occurring at the expense of the ileum. In the iliaca-ileo-colic type the appendix disappears as the stage of invagination of large intestine proceeds.

The reduction of the tumour is now proceeded with. By pressure on the apex of the intussusceptum the invaginated portion is manipulated in a retrograde direction, and bit by bit the inversion is undone until reduction is complete.

There are many cases in which the process of reduction is associated with difficulties. The various possibilities and the methods of dealing with them will now be discussed.

(1) When reduction is difficult but apparently not impossible It is often urged that it is dangerous to pull on the entering loop in the attempt to reduce the intussusception, this danger has been exaggerated, and, if reasonable care is employed, a gentle pull upon the entering loop is often sufficient to reduce the tumour If difficulty still exists, a manoeuvre of great value should be put into use The intussusception, wrapped in a warm wet towel, is placed on the palm of the operator's hand or hands, care is taken to ensure that equal contact is exerted all around, and in this position the tumour is firmly squeezed The effect is to displace a certain amount of œdema and hæmorrhage from the bowel wall into the lumen The bulk is therefore reduced, and reduction is correspondingly easier In many cases we have proved this plan to be of great value

If, in spite of these measures, there is still difficulty, we increase the reduction force—the peritoneal coats begin to tear, but the tears for the time being are disregarded and the force is continued A case which appeared irreducible may now yield and reduction be completed In this event it is essential to go carefully over the bowel wall and to suture each peritoneal tear individually It is in the large intestine that this precaution is so essential, because failure to observe it will result in an infection passing through the bowel wall and establishing a slow but fatal peritonitis, the risk does not appear to be so great in the case of small intestine tears

(2) When reduction is impossible When it is apparent that reduction is impossible the surgeon is faced with one of three possibilities —

(a) Complete resection of the intussusception with intestinal anastomosis

(b) Resection of the intussusception with subsequent enterostomy

(c) The intussusception is left *in situ* wrapped in omentum while a proximal temporary enterostomy is done

(a) *Resection and Anastomosis* In spite of the high mortality which is associated with this operation it is in many respects the most satisfactory procedure, and a side implantation of the ileum into the transverse colon is the most suitable type of anastomosis, a speedy operation being essential if a successful result is to be obtained

(b) *Resection and Enterostomy* Resection of the intussusception and the insertion of a small Paul's tube into the open end of the bowel has proved a disappointing method The upper fistula is usually a small intestine one, and the majority of children die within a few days from inanition

(c) *Temporary Enterostomy and Retention of the Intussusception* If the general condition of the patient forbids resection and anastomosis, this is probably the best course to adopt The intussusception is wrapped in omentum, and the latter is fastened to the bowel wall with a number of catgut sutures An enterostomy is done on the

proximal loop of bowel in order to allay the intestinal obstruction; this is best done by the 'Coffey' method of lateral implantation of a catheter into the bowel. The objections of a complete fistula are thus avoided, and at a subsequent date, when the urgent symptoms have subsided, a resection and anastomosis may be carried out.

VOLVULUS

Definition. A volvulus of the intestine is said to be present when the bowel is twisted or has undergone an axial rotation.

VARIETIES. There are three possible axes about which twisting may occur :—

- (1) The intestine may twist upon its own longitudinal axis—an uncommon occurrence.
- (2) A coil of intestine rotates around the axis of its mesentery—the most frequent variety of volvulus.
- (3) Two adjacent coils of intestine with their related mesenteries may coil around each other in a fashion very similar to that of a creeper around a stick. In this type of volvulus one mesentery usually forms the axis around which the other twists.

ETIOLOGY

Both predisposing and exciting causes have to be considered.

Predisposing Causes. The arrangement of the mesentery of the small intestine is so accurately adjusted that volvulus cannot occur unless some abnormality of the mesenteric attachment exists. Three different types of abnormality are met with :—

- (a) Narrowing of the mesenteric attachment.
- (b) Abnormal length of the mesentery.
- (c) The formation of an adventitious bowel attachment such as an adhesion.

(a) *The Mesenteric Attachment.* The essential feature of a normal mesentery is that every piece of intestine has as its base of attachment the whole extent of the origin of the mesentery, and anything which narrows the base is a predisposing cause of volvulus. The common influences which produce the narrowing are adhesions between coils of intestine producing a fixed loop, inflammation of a mesenteric gland, resulting in resolution and contraction, tuberculous or simple ulceration of the bowel wall with resulting fibrosis and contraction of the mesentery. This last factor is of special importance in the region of the sigmoid colon.

(b) *Abnormal Length of the Mesentery.* An infant may be born with an unusually long mesentery to any portion of the intestine. The occurrence is most frequent at the ileo-cæcal junction, where the presence of a mesentery to the cæcum and ascending colon results in a common mesentery for the small intestine, cæcum and ascending

colon Children may acquire an abnormally long mesentery from the presence of a large hernia sac which is constantly filled with intestine

(c) *The Formation of an Adventitious Bowel Attachment* This is an especially dangerous predisposing factor If an adhesion passes from the wall of a loop of small intestine to the mesenteric surface the result is that a portion of the loop is suspended by an adventitious mesentery with a narrow point of attachment, and in such an event there is a constant danger of rotation occurring around the abnormal pedicle

Exciting Causes In the presence of predisposing factors the final twist is produced by some sudden effort such as turning quickly, lifting or straining Distention of a loop of intestine sometimes appears to be the exciting cause

PATHOLOGY

An *ileo caecal* or *entero colic* volvulus is the most common type in the child, and the existence of a congenital mesenteric attachment to the ascending colon is the predisposing cause An *enteric* volvulus is sometimes found, and it often arises secondary to the adhesions which follow a tuberculous peritonitis or a *tubercles mesenterica* A volvulus of the sigmoid, such as is met with in adults is very uncommon in the child

Various degrees of twisting may occur, from half a complete circle to three or even four turns When the torsion is slack the obstruction is incomplete, and the bowel may adapt itself to the arrangement except for some degree of distention When the twist is tight however, evidences of strangulation become apparent As the veins are the first structures to suffer, intense venous engorgement results, and the related loop of bowel becomes purple in colour and oedematous, the tension on the capillaries results in hæmorrhage, and blood is extravasated into the tissues The mucous membrane pours a profuse blood stained exudate into the bowel lumen, and a similar secretion appears within the peritoneal cavity Gas, formed partly from bacteria within the intestine and partly from CO_2 , collects within the bowel, so that there is an enormous distention of the affected segment, and if the torsion is allowed to persist, the interference with the blood supply may result in gangrene If the interference with the blood supply is not complete the process is more gradual the distention continues, the peritoneal coat may rupture under the strain, and a migration of organisms begins to occur through the bowel wall so that peritonitis develops

It is interesting to note that perforation of the affected loop rarely ensues, if rupture takes place it is usually in the bowel above the twist

CLINICAL FEATURES

The onset of symptoms is usually sudden Pain is the first evidence of the disorder, it is severe, with exacerbation of the nature

of colic, and it is directly referred to the region in which the volvulus has occurred. Coincident with the appearance of pain there may be vomiting, but this feature disappears to re-appear later when complete obstruction develops. Similarly, the lower bowel may pass a normal motion soon after the development of the pain, probably because of an active peristalsis secondary to the irritation of the volvulus.

In a short time the features become those of an acute intestinal obstruction. The pain, after reaching a stage of intense agony, begins to subside in intensity, vomiting returns and becomes persistent, a small amount of blood-stained mucous may escape from the rectum, and some tenesmus may accompany the discharge.

The **abdominal signs** are distinctive. At first the abdomen is retracted with distinct muscular fixation over the region in which the volvulus lies. This region is also tender to the touch, and, if the examination is made while the abdominal wall is relaxed, it may be possible to distinguish the presence of an enlarged and tense loop of intestine.

The abdomen later becomes distended, the degree and distribution of the distention depending upon the type of the volvulus. In the ileo-cæcal type there may be a resonant tumour in the right half of the abdomen; in enteric volvulus the distention may be limited to the umbilical region.

The accumulation of free fluid within the abdomen is a characteristic sign, and its demonstration may decide the diagnosis. In a late stage the abdominal signs are those of a progressive peritonitis.

DIAGNOSIS. Certain features should suggest the possibility of volvulus: these are the sudden onset of intense abdominal pain, the onset of an intestinal obstruction, at first incomplete and afterwards complete, the localized abdominal distension which is often manifest, and the accumulation of free fluid within the abdominal cavity.

PROGNOSIS. Spontaneous reduction of the volvulus is possible, but such an event can only occur in the very early stages. Apart from this rare possibility, the prognosis depends upon the stage at which surgical operation is performed. In severe cases the prognosis is extremely grave; many of the recorded statistics show a mortality of 80 per cent.

TREATMENT. Surgical operation is invariably necessary, and the earlier it is carried out the more hopeful the prospects.

The abdomen is opened by a middle line or paramedian incision. The nature of the ailment is recognized by the blood-stained fluid within the abdomen, and by the protrusion into the wound of the distended and engorged gangrenous coils of intestine. If the distension is great, the affected coils should be punctured and emptied, and the puncture wounds closed with catgut. The volvulus is then removed from the abdomen, and, if possible, the twist is undone.

It is unwise to remove the volvulus from the abdomen before the distention is relieved, as the sudden release of pressure may be followed by a rupture of the bowel. If the bowel involved has become gangrenous, it is resected, and an end to end anastomosis is performed.

If reduction of the volvulus has been possible, an effort should be made to prevent its recurrence. In the ileo cæcal type this may be done by anchoring the cæcum and the ascending colon to the posterior abdominal wall. The prevention of the recurrence of enteric volvulus is more difficult, but any band or adhesion which has altered the mesenteric arrangement should be dealt with.

CONGENITAL DILATATION WITH HYPERTROPHY OF THE COLON

This is an obscure disease of the large intestine, in which the essential features are an inability of the colon to part with its contents, and a resulting distention of the bowel with hypertrophy of its wall. Male children are more commonly affected than females in a proportion of about five to one.

The disease was first described by Hirschsprung of Copenhagen in 1886, when he published an account of the ailment as occurring in infants aged eleven months and seven months respectively.

CLINICAL HISTORY

An observant mother notices that the child is developing what apparently is an intractable constipation. Many days may elapse during which there is no motion, and this feature is as a rule first noticed during the first three months of life. Purgative medicines of various descriptions are brought into use or enemata are employed, and, as a result of these, an evacuation is secured. It is noticed—and the point is important—that the motion now passed is not a constipated one, but is a large soft motion.

The process is repeated, and after some months it is apparent that the abdomen becomes distended during the period of constipation, and that relief of the constipation diminishes the distention. That the distention is largely a question of flatus is proved, because, when a rectal tube is passed, a quantity of wind escapes and the child is relieved.

As the disease advances the constipation becomes more marked, and the stools alter in consistency, for they remain so long in the bowel that they become firm or even scybalous and hard. Intervals of from two to three weeks may elapse during which no motion is passed, while the abdominal distention slowly but progressively increases. Attacks of diarrhoea now make their appearance—they follow a prolonged interval of constipation, and they are traceable to some degree of colitis or even of stercoral ulceration of the colon wall from the long continued pressure of the contents. The diarrhoea fails to relieve the sufferer, instead, it is accompanied by increased

distention, by pain and by loss of weight. It is important to notice that, apart from the intervals when the diarrhoea occurs, the child maintains wonderfully good health, eating well and suffering comparatively little abdominal pain or discomfort, while vomiting is rare.

Very slowly the disease progresses, the abdominal distention increases, and, should the patient survive to adult life, it may attain immense proportions. Coincident with the abdominal enlargement the general nutrition suffers, the child becomes wasted, with a pale and toxic appearance, and the abdominal distention affects the surrounding viscera and even the related skeleton, the margin of the lower ribs being everted, and the sub-costal angle permanently opened out. The thoracic viscera are displaced upwards into the thorax, the surface veins of the abdomen are distended, and in the terminal



FIG. 435.—Hirschsprung's Disease

The distended abdomen is the result of the enormous increase in size of the large bowel
The large abdomen is in striking contrast to the general body wasting.

stages there may be œdema of the legs, scrotum, and lower abdominal wall. The distention has so thinned the musculature of the abdominal wall that the outline of the large colon can be made out; at intervals, contraction of the intestine may be apparent, while a resonant note can be elicited over the abdomen and sometimes faecal masses can be palpated.

If the disease is untreated, it almost invariably ends fatally, though a few individuals reach adult life. The child either succumbs to a toxæmia, one of the features of which is a profound secondary anæmia, to an acute intestinal obstruction which cannot be relieved, or to peritonitis from perforation of the bowel wall.

A very curious fact has been recorded in the clinical history of many cases; sometimes the colon suddenly assumes its normal function and continues to act naturally for a period of as long as a

year at a time, when it relapses without any obvious reason into its former sluggish condition

MORBID ANATOMY

The evidence which we possess shows that the disease begins at the junction of pelvic colon and rectum, and that the changes which are there apparent are gradually propagated backwards along the colon. It is further accepted that the morbid changes are strictly limited to the distended colon and to the consequences of the distention. No stricture, volvulus kink, or organic obstruction has ever been found which would account for the condition.

When the affected colon is examined it is found to be distended, to be hypertrophied, and in many cases to show evidences of ulceration in its lining mucosa. The distention is most marked in the pelvic colon, and progressively diminishes as the colon is ascended. The hypertrophy of the bowel wall may attain as much as $\frac{1}{2}$ inch, and both the circular and the longitudinal fibres are affected. There is a great increase in length of the colon in severe cases, though the hypertrophy is limited to the sigmoid. It is of interest to record that the rectum is usually contracted and normal.¹ The other abdominal organs are displaced by the enormous distention of the lower part of the colon.

ETIOLOGICAL PATHOLOGY

There is much diversity of opinion in regard to the explanation of the changes just described. The essential error appears to be that the pelvic colon is unable to expel its faecal contents into the rectum. The function of the descending colon and the lower colon is that, while they extract a certain amount of fluid from the faeces, they store their contents until a convenient occasion arises for their evacuation, and most likely this latter storage function is aided by the existence of a sphincter which separates the pelvic colon from the rectum. The reflex which induces the contraction of the lower colon is apparently the mechanical contact and irritation of the mucous membrane by faecal matter, and the distention of the colon by flatus. In Hirschsprung's disease it would seem that there is a depression of the normal reflex and most likely the depression depends upon an imperfect distribution of the Auerbach's and Meissner's nerve plexuses in the bowel wall. In these cases a normal quantity of faeces or flatus collected in the sigmoid is insufficient to excite expulsion, and it is only when the bowel has become considerably distended by the accumulation of faecal matter that a sluggish reflex is excited. The amount of faecal matter with which the bowel now has to deal is, of course, beyond its powers unless aided by copious enemata, but the violent though occasional efforts which ensue lead ultimately to a great hypertrophy of the bowel wall.

¹ In some cases the distention and hypertrophy affects the rectum and extends upwards from the point of junction of the rectum with the anal canal.

DIAGNOSIS

The diagnosis of congenital idiopathic dilatation of the colon readily made from the symptoms, while an actual demonstration of the degree of distention can now be afforded by an X-ray examination with an opaque enema.

Difficulty may arise in excluding a dilatation and hypertrophy of the colon which is secondary to an obstruction in the bowel wall and its surroundings; a bismuth enema may make the distinction clear, but in many cases laparotomy alone will decide the point.

Barrington Ward has directed attention to the necessity of distinguishing typical cases in young children from cases of faecal impaction consequent on spasm of the sphincter set up by anal spasm or from the presence of a valve in the rectum (Delbet).

The abdominal enlargement associated with tuberculous peritonitis has been confused with Hirschsprung's disease.

PROGNOSIS. In the absence of surgical treatment the disease almost invariably ends fatally, and only a few of the patients survive to adult life.

TREATMENT

Palliatives. It is necessary to consider a palliative line of treatment, as many cases are unsuitable for operation for a variety of reasons.

When the condition is recognized the immediate indication is to empty the colon as effectively as possible. Purgatives are contra-indicated unless other means fail, because they increase the distention of the already exhausted colon. A high rectal tube is first passed, in order to effect the escape of any gas or fluid faeces which may have accumulated, after which the solid faeces are removed. The persevering use of soap and water enemata is usually successful; a molasses enema sometimes succeeds when others fail. If the upper reaches of the rectum contain an impacted mass of hard faeces, it may be necessary to administer an anæsthetic and to manually remove the accumulation.

When the colon is empty, a regular course of laxatives is begun, and aloes with nux vomica is the most efficacious. Every second or third day a soap and water enema should be administered.

It must be realized, however, that a course of treatment of this nature is at the best only palliative; there is a constant tendency to relapse, and ultimately the condition is re-established in spite of every effort.

Operative (Curative ?) Treatment. The only curative treatment which the pathology and clinical course of the affection show to be applicable is that of excision of the affected bowel with the union of unaffected gut above to the upper end of the rectum below. In the infant such a radical procedure, however, is impossible owing to the

degree of shock which is produced, and in the case of the very young child operative interference is limited to an attempt to diminish the bowel lumen by plication of its walls

At one time it was hoped that the making of a faecal fistula into the affected bowel might result in shrinkage, but this hope is rarely fulfilled, because the fistula does not always relieve the accumulation of gas

If the condition of the child is favourable, implantation of the



FIG 436—Hirschsprung's Disease. Congenital idiopathic dilatation of the colon treated by colostomy

Nearly twenty years have elapsed since the operation and apparently a complete recovery has been made (Sir H. Stiles case)

ileum into the rectum, with subsequent removal of the affected colon, offers the best chance of success

INTESTINAL OBSTRUCTION

Most of the facts concerning intestinal obstruction which are related in connection with the adult are equally applicable to the child, but when the surgery of childhood is being considered there are definite peculiarities of the intestinal obstruction of the child which demand special notice. In this chapter, therefore, the special aspects receive attention, and general facts are only alluded to in explanation of special points

DEFINITION AND CLASSIFICATION Intestinal obstruction is a condition in which the intestinal contents are more or less hindered in their passage along the bowel, it being accepted, of course, that a definite lesion exists which is responsible for the delay. The clinician

DIAGNOSIS

The diagnosis of congenital idiopathic dilatation of the colon is readily made from the symptoms, while an actual demonstration of the degree of distention can now be afforded by an X-ray examination with an opaque enema.

Difficulty may arise in excluding a dilatation and hypertrophy of the colon which is secondary to an obstruction in the bowel wall and its surroundings; a bismuth enema may make the distinction clear, but in many cases laparotomy alone will decide the point.

Barrington Ward has directed attention to the necessity of distinguishing typical cases in young children from cases of faecal impaction consequent on spasm of the sphincter set up by anal spasm or from the presence of a valve in the rectum (Delbet).

The abdominal enlargement associated with tuberculous peritonitis has been confused with Hirschsprung's disease.

PROGNOSIS. In the absence of surgical treatment the disease almost invariably ends fatally, and only a few of the patients survive to adult life.

TREATMENT

Palliatives. It is necessary to consider a palliative line of treatment, as many cases are unsuitable for operation for a variety of reasons.

When the condition is recognized the immediate indication is to empty the colon as effectively as possible. Purgatives are contra-indicated unless other means fail, because they increase the distention of the already exhausted colon. A high rectal tube is first passed, in order to effect the escape of any gas or fluid faeces which may have accumulated, after which the solid faeces are removed. The persevering use of soap and water enemata is usually successful; a molasses enema sometimes succeeds when others fail. If the upper reaches of the rectum contain an impacted mass of hard faeces, it may be necessary to administer an anæsthetic and to manually remove the accumulation.

When the colon is empty, a regular course of laxatives is begun, and aloes with nux vomica is the most efficacious. Every second or third day a soap and water enema should be administered.

It must be realized, however, that a course of treatment of this nature is at the best only palliative; there is a constant tendency to relapse, and ultimately the condition is re-established in spite of every effort.

Operative (Curative ?) Treatment. The only curative treatment which the pathology and clinical course of the affection show to be applicable is that of excision of the affected bowel with the union of unaffected gut above to the upper end of the rectum below. In the infant such a radical procedure, however, is impossible owing to the

THE SPECIAL CONSIDERATIONS OF THE PATHOLOGY

The Liability to Strangulation In the majority of cases of acute intestinal obstruction in the child, not only is the lumen of the intestine suddenly and completely interrupted, but a coil of intestine is strangulated in addition. It may be that a band has become noosed around the bowel, that the intestine has passed through a hernial ring, that axial rotation has occurred with the production of a volvulus, or

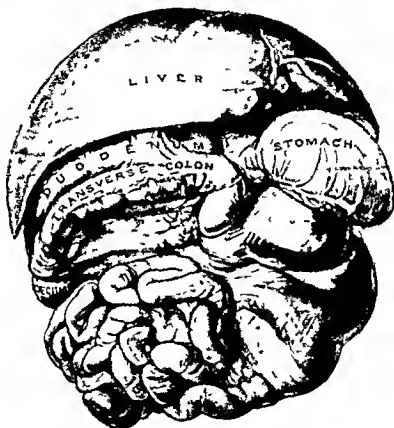


FIG 437 —Congenital Atresia of small Intestine (New born baby)

Specimen of abdominal viscera showing a congenital obstruction of the small intestine at a point 16 centimetres beyond the duodeno-jejunal junction. The distention of the duodenum and the upper coils of the small intestine is well shown.

that a part of the intestine is invaginated within a part below and gripped by it, as in an intussusception. The realization of this point is important, as it so closely affects the treatment, for not only has the obstruction to be relieved, but the strangulated segment of bowel may demand individual attention.

The Rapidity with which Distention occurs When a case of acute obstruction is operated on, the bowel below the obstruction is found to be empty, contracted, and pale. The experiments of

generally divides the different varieties of the disorder into three groups :—

- (1) Acute intestinal obstruction.
- (2) Chronic intestinal obstruction.
- (3) A chronic intestinal obstruction which suddenly becomes acute.

While this method of classification is applicable to the child, the term congenital or acquired may be added with advantage, for, as we shall show, much of the intestinal obstruction of infancy is related to errors of development which may be termed congenital. A third sub-division is related to the situation in which the cause of the obstruction exists, and therefore it is convenient to recognize *mural*, *intra-mural*, and *extra-mural* regional varieties of obstruction.

Acute Intestinal Obstruction (considered from a general aspect)

ETIOLOGY

There is such a wide variety of possible causes of acute intestinal obstruction that there are advantages in considering the possible etiological factors in relation to the age period at which the disease appears. Such a method is more practicable in children than it would be in adults, and while of course it must at its best be of a provisional nature, the method is helpful from a clinical standpoint. In the course of teaching we are in the habit of tabulating the possible causes as follows :—

A. If obstruction develops either at birth or within a few days after birth	the most likely causes are	{ Congenital atresia Imperforate anus Congenital volvulus
B. Obstruction developing at some time during the first three years of life	" "	{ Acute volvulus Intussusception Meckel's diverticu- lum and the related vitello - intestinal vestiges.
C. Obstruction developing after the third year	" "	{ Acute volvulus Appendicitis Tuberculous peri- tonitis (bands and adhesions) Internal and exter- nal herniæ.

Such a classification must of course be of a strictly provisional nature, but it is helpful to realize that the suggestions which it embodies are often correct. The exact etiology of the various types is considered under individual headings.

influence of vomiting must always be kept in view, and appropriate steps taken for its control

Collapse is more evident in the child than in the adult. There are two processes, very different in type, which are often included under the term 'collapse'. Firstly, there is a powerful sympathetic or vagus stimulus such as occurs when a loop of bowel becomes suddenly strangulated, a stimulus which leads to a sudden fall of blood pressure and a combination of general features which are appropriately grouped under the term collapse—this disturbance is often apparent in the child. In the later stages of intestinal obstruction, however, the acute toxæmia gives rise to a train of symptoms which are also collectively spoken of as collapse, and it is to this group that in the child great importance should be attached, for they often develop with great suddenness and, having once developed, they may rapidly lead to a fatal termination. This feature is perhaps one of the most characteristic of the acute obstruction syndrome of children, the threshold between a tolerance of the obstruction and an intense toxæmia is apparently a very narrow one, and the practical importance of the observation is that no delay is permissible in the treatment of the disorder.

CONSIDERATIONS OF DIAGNOSIS

One often finds that there is dubiety regarding the conditions under which it is permissible to make a diagnosis of acute intestinal obstruction. If an individual suffers from vomiting coupled with the absence of contents from the bowel, either flatus or faeces, a diagnosis of complete intestinal obstruction should be made. The clinician has then to decide whether it is an acute development or the exacerbation of a previous chronic obstruction, and the clinical history will afford the information which is necessary to decide the question. It is most important to decide whether the obstruction is a 'high' or a 'low' one, or (put in another way) whether it has originated in the small or large intestine. Certain facts may enable the distinction to be drawn, a high (small intestine) obstruction is characterized by early and profuse vomiting, by a rapid development of collapse, and by a variable degree of abdominal distention. A high (small intestine) obstruction may, for example, show practically no distention beyond a swelling in the epigastrium, which is due to the stomach and duodenum, and which temporarily diminishes when vomiting occurs. A low (large intestine) obstruction has characteristics of an opposite character, the vomiting is late, the degree of collapse and pain are less, while the amount of abdominal distention is considerable, uniform and steadily progressive.

The diagnosis will conclude with a decision regarding the cause which has been responsible for the obstruction. The origin may be manifest at the first examination, as in cases of imperforate anus, or by the demonstration of the tumour of an intussusception, on the

Bayliss and Starling have shown that experimentally the first result of resisting the progress of intestinal contents is powerfully to augment the peristaltic wave above the obstructed point and to paralyse and relax the intestine for 3 feet below it. It is in this way that the intestine attempts to overcome the obstruction. Soon, however, peristaltic waves pass along the bowel over the obstructed point, and, continuing along the intestine, render it contracted and empty.

Above the obstruction the bowel wall is at first thin, pale, and distended, but in a short time the wall becomes thickened by œdema and congested with blood. At first the contents of the bowel are liquid and pultaceous, and only to a small extent gaseous, but when the blood supply becomes so interfered with that absorption ceases, there is a rapid formation of gas. The degree of distention of any coil of intestine is ultimately limited by the resistance of its own wall and the pressure exerted upon it by the abdominal coverings and the adjacent coils of intestine.

In the child, the factors which govern the distention are so affected that an extreme degree of dilatation rapidly occurs. This point has its practical bearing, because to permit the stage of distention to be reached is likely to be disastrous.

The Liability of the Peritoneum to be infected. Even before a coil of gut is actually gangrenous it loses its power of preventing the passage of organisms from its lumen through its wall to the peritoneum. This liability is greater in the child than in the adult.

The Small Intestine is usually affected. If the etiology is considered, it will be seen that, with one or two exceptions, all the examples of acute intestinal obstruction in the child affect the small intestine. The practical bearing of this fact is of immense importance, for, as we shall note later, the shock, pain, vomiting, and distention are all thereby at their maximum.

SPECIAL CONSIDERATIONS IN REGARD TO SYMPTOMS

There are four symptoms which usually indicate the development of an acute intestinal obstruction—pain, vomiting, collapse, and constipation; these are as constant in the child as in the adult.

If strangulation of bowel is present, the pain which proceeds from this is especially severe, and, as strangulation bulks largely in the pathology of obstruction in the child, this symptom is correspondingly predominant.

Vomiting is most evident in the obstruction of small intestine, and we have alluded to the large proportional incidence of small intestine obstruction in children; vomiting is therefore a marked feature in a large percentage of the cases. A rapid loss of fluid is a serious detriment to the delicate economy of the child's body; it may quickly lead to an alarming degree of acidosis, and from this aspect the dehydrating

certainly either the locality of the obstruction or the pathological process which has been responsible for it. In such a case it is our practice to open the abdomen so as to expose the ileocaecal region. This is done either by a right para median incision or by a muscle-splitting incision in the right iliac fossa, an increased access being obtained if necessary by carrying the transverse split of the internal oblique and transversalis muscles into the sheath of the rectus muscle.

Inspection of the ileo caecal junction affords information regarding the situation of the obstruction—a dilated caecum means a large intestine occlusion, a contracted caecum indicates a small intestine obstruction. The next step is to isolate the actual site of the obstruction, and according to the information which the caecum has afforded the exploration will be carried in a proximal or distal direction. It is important to avoid much evisceration.

When the local obstruction has been isolated, the aim of the operator is to free it, the band is divided, the intussusception reduced, or the volvulus undone. But unfortunately there are many cases in which the issue is by no means straightforward, for one or other of various complications exists.

1 The bowel above the obstruction may be so greatly distended that removal of the mechanical cause of the obstruction may be insufficient to relieve the paralysed bowel. In such an event emptying of the distended segment is necessary, and this calls for a special technique. The use of a Paul's tube is unwise, the immediate emptying of the bowel by a glass tube, such as is sometimes practised in the adult, being absolutely contra indicated in the child, because a fatal peritonitis is likely to ensue. The safe and efficient method is by the use of a catheter enterostomy employed according to Coffey's method, in this way no soiling of the peritoneum takes place, the relief of tension which results is sufficient to allow the bowel to recover, and, when the normal passage has been re established, the catheter can be removed without further operation and without any persistent fistula.

2 When the obstruction site has been located it may be found that it is impossible to relieve the error. In this event any immediate attempt at division and anastomosis of the bowel is contra indicated, and a proximal catheter enterostomy or caecostomy is used instead, to temporarily relieve the obstruction, at a later date, when the acute symptoms have subsided, suitable arrangements are made to remove the obstruction or to short circuit the bowel, if removal is impossible. In this latter connection an end to side anastomosis of small intestine to transverse colon is a very successful operation in the child.

3 It may be found that the obstruction is a multiple one. Thus, the most embarrassing and distressing of all types of acute obstruction, is met with in tuberculous peritonitis, and it is really very difficult to know how to deal with it. Adhesions are numerous, many coils are distended, and the operator is unable to say where the actual

other hand, the cause may remain obscure until a laparotomy has been performed.

THE PROGNOSIS

The prognosis is naturally affected by the cause which has originated the obstruction, and therefore each type has to be considered separately. On a general basis, it may be said that obstructions arising from congenital errors are the most serious, while those which have a mechanical origin, such as intussusception and volvulus, are more hopeful. But from a practical point of view, the age of the child and the length of time during which the obstruction has been in existence are factors of immense importance. Babies are peculiarly intolerant of intestinal obstruction; the loss of fluid and the toxic absorption which the process entails rapidly lead to a fatal issue. The importance of the time duration has been already alluded to in discussing the symptomatology—the step from tolerance to collapse is especially narrow where children are concerned.

A CONSIDERATION OF TREATMENT

When a diagnosis of acute intestinal obstruction has been made immediate operation is imperatively demanded; delay will only prejudice the chances of recovery.

The type of operation demanded will vary according to the variety and situation of the obstruction, and therefore only general facts can be discussed at this stage.

Pre-operative Treatment. The precautions which are necessary in adult work are even more important when dealing with children.

Body warmth should be maintained by the use of an electric cradle; it diminishes shock, and delays the onset of collapse.

Saline infusions are necessary in order to counteract the dehydration by vomiting which has probably occurred. A child deprived of fluid is especially susceptible to acidosis with all the additional risks which this complication entails. As the fluid cannot be administered orally, it is best given by subcutaneous administration: proctoclysis is unlikely to result in much absorption of fluid.

Atropine should be administered hypodermically, as it lessens the secretion, and thus gives a certain amount of comfort.

Gastric lavage must always be carried out. Anæsthesia should not be administered until the stomach has been washed out, and, even apart from the pre-operative necessity, the treatment gives great temporary symptomatic relief.

Enemata are indicated if there is any suggestion that the bowel below the obstruction contains fæcal matter.

The Operation in a Case of Obstruction of unknown Origin. In a certain proportion of cases, the clinician will find that, while he is able to diagnose an acute obstruction, he is unable to distinguish with

changes in the periductal tissues resulting in destruction of the ducts or in obstruction of their lumen.

THE PATHOLOGY has no uniformity. The ducts may be partially obstructed with thickened walls, they may exist as fibrous cords, or they may be entirely absent in part or in whole, we have seen several cases in which the gall-bladder has been entirely absent. There is often considerable distention of the ducts above the site of the obstruction.

TREATMENT It has always been our practice to give these cases the possible chance of relief which operation affords. Holmes estimated that about 16 per cent might be relieved if not cured by an anastomosis between the gall bladder or the dilated ducts and the stomach, and, in view of this, it is advisable that all cases should at least have the opportunity of relief by laparotomy. Hitherto the risks of the operation have been accentuated by a tendency to post-operative hæmorrhage, but Rosenow has shown that by the injection of 30 per cent sodium citrate a few hours before operation this danger can be avoided. For a newborn baby 1 to 2 c.c. of the solution is sufficient.

Jaundice from umbilical sepsis has points of interest for the surgeon. We have alluded elsewhere to the importance of infection of the stump of the umbilical end, and the subject under discussion is a concrete example of the risks.

A streptococcal infection is incurred at or soon after birth, the cord is moist, sloughy, and discharging pus from its extremity, and the region of the umbilicus is red and oedematous. From this focus, infection extends along the umbilical veins into the portal fissure of the liver, from which it spreads throughout the organ. The distribution of the infection is chiefly in the periductal tissues of the finer ducts, catarrhal changes appear in the lining epithelium, and jaundice develops which is obstructive in its nature.

Unfortunately the condition is associated with widespread septic disturbance— inflammatory reactions appear in the various serous membranes, in the pleura, the peritoneum and the meninges, and some degree of streptococcal septicæmia is inevitable.

The clinical evidences of the disease are characteristic. Subsequent to the local umbilical infection there is considerable general disturbance, the baby becomes restless and irritable, the breast or bottle is refused, and there may be vomiting, the temperature is found to be high (104° or 105°). Within a day or two, jaundice develops and deepens. In a severe case there is a general body oedema with cyanosis, and, if the jaundice has persisted for some time, hæmorrhages appear. As may be imagined, the disease is an exceedingly fatal one.

The best treatment is preventive, for with care in the asepsis of the umbilical stump the disease will not occur.

An established case is a difficult problem. Fomentation dressings are applied to the septic cord, minute doses of calomel are administered, normal horse serum is given intra-muscularly and in severe cases blood transfusion is of value.

obstruction exists. In such an event, any bands which seem to be causing obstruction are divided, a catheter enterostomy is done into the most distended segment of the bowel, and any loop of intestine which appears to be obstructed is similarly relieved. It is one of the advantages of the catheter method of enterostomy that a number of fistulae may be established without any real additional risk. By this method the acute period is tided over, and if it is apparent that the obstruction still persists, a short-circuit operation is then performed.

LIVER AND BILE DUCTS

Only a very few of the diseases which affect the liver and its bile ducts are amenable to surgical treatment. The subject may be discussed under :—

- (1) The surgical aspects of jaundice. (2) Tumours of the liver.

THE SURGICAL ASPECTS OF JAUNDICE

An infant on the second or third day after birth shows an evanescent jaundice of a peculiar and characteristic type. The explanation of the event is a matter of dispute, but the most recent views hold that it depends upon a massive destruction of red blood corpuscles which results in the production of such a large amount of bile that a certain proportion of it finds its way, by some obscure channels, into the general circulation. The jaundice disappears at the end of a week or ten days, and is so constant that it may be considered physiological.

In certain instances, however, the appearance of jaundice in the newly born has a more serious import, for it may indicate the existence of congenital obliteration of the bile ducts, and, as this condition is occasionally amenable to surgical interference, it demands attention.

The infant is well nourished at birth, and about the second or third day a jaundice develops which is thought to be of the harmless physiological type (*Icterus neonatorum*). When the first stool is passed suspicions are aroused because the motion is colourless. Thereafter the jaundice gradually deepens until the skin assumes a dark greenish-yellow hue. The urine which is passed is deeply stained with bile.

During the early stages of the disease, hæmorrhages may occur, bleeding taking place into the subcutaneous tissues from the umbilicus or from the mucous membranes. In this event the further progress of the disease is generally towards an early fatal issue. If hæmorrhage is slight or absent the child may live for several months without much constitutional disturbance.

THE ETIOLOGY of the disease is obscure. Cases have been recorded in which hereditary influences are manifest. Many believe that a pre-natal infection is responsible for the disorder, inflammatory

and continued vomiting at frequent intervals. The condition was ascribed to acute indigestion, and a dose of castor oil was administered, but immediately vomited. The pain and sickness continued, and the most remarkable feature of the case now began to make its appearance—a rapidly increasing distention of the abdomen. Within twelve hours of the onset of the disease, the abdomen was distended as tight as an inflated balloon. The sickness continued, the abdominal distention gave rise to considerable respiratory distress, and the skin surface had a curious cyanotic appearance.

On PHYSICAL EXAMINATION the various points already detailed were observed. The abdomen was tender particularly in the upper half. Pressure below the last rib on the right side elicited pain. Rectal examination was negative. The temperature was 103° , pulse, 140, respirations, 38. The white blood cells numbered 15,000, with 72 per cent of polymorphs.

A DIAGNOSIS of acute appendicitis with secondary acute intestinal obstruction was made, and it was surmised that the appendix lay in a retrocaecal position.

Operation revealed a quantity of blood stained fluid in the abdomen, a routine examination of the appendix showed it to be normal. The upper abdominal viscera showed distinct signs of inflammatory reaction, and the transverse mesocolon contained several points of fat necrosis. The pancreas was found to be acutely inflamed, with numerous points of hæmorrhage and fat necrosis. Local drainage was instituted, the gall bladder was not opened.

The outstanding feature of the case was the extraordinarily rapid distention of the hollow viscera, it gave one the impression that some paralysing influence was at work on the sympathetic system, and, in view of the findings at operation, it might be that the distention was the result of an infection of the retro peritoneal tissues.

PANCREATIC ABSCESS

Boy, aged $5\frac{1}{2}$ years. The illness began on a Friday night. The child had gone to bed in good health, he awakened during the night complaining of upper abdominal pain so severe that he writhed about the bed. There was vomiting, but this did not appear to relieve his discomfort. The following day (Saturday) castor oil was given with out result. Sickness persisted, and the abdominal pain continued, though less in degree. On the evening of this day the abdomen was observed to be distended, and the child was cold and collapsed.

On the Sunday the child was first seen by a medical man, who found the abdomen distended and tender. A purgo and enema were given, and the bowels moved with a watery and very foul result. During Monday the condition remained much the same—there was sickness at intervals.

Buhl's disease and *Winckel's disease*—conditions associated with jaundice, the exact nature of which has hitherto remained obscure—are probably traceable to septic infection in which the organisms have gained entrance through the umbilicus.

During the period of childhood many other varieties of jaundice may be met with—*catarrhal jaundice*, *congenital acholuric jaundice*, *cirrhotic jaundice*, *acute infective jaundice*—but none of them possesses surgical aspects unless it be the cirrhotic type.

In the two varieties of *cirrhotic jaundice* associated with childhood—the *monolobular or biliary form* (*Hanot's cirrhosis*), and the *intercellular syphilitic cirrhosis*—ascites becomes a prominent feature in the later stages. In one case of biliary cirrhosis the author carried out the Talma-Morrison operation with a considerable measure of success. The operation was performed in 1914, and when last seen the boy was well, and practically free from ascites.

TUMOURS OF THE LIVER

The surgical interest of liver tumours is in relation to questions of diagnosis.

Both benign and malignant tumours are encountered in childhood. Of the former group, hæmangiomata and cysts are the most common. Parasitic cysts arise in connection with distomum hepaticum, ascarides, echinococcus and pentastomum denticulatum. Malignant tumours are more frequent than might be imagined. Stiffel collected thirty-nine cases of primary malignant new growths in children, several of which were in the newborn. The pathology is usually that of an adeno-sarcoma. Sarcomatous tumours are very rare events.

THE PANCREAS

The literature is largely silent on questions of pancreatic disease in infancy, and, except in regard to pancreatic infantilism, the affections of this organ are omitted from most pediatric textbooks. Occasionally, however, acute disease of the organ has to be considered in the diagnosis of acute abdominal conditions in childhood.

We have met with three examples of acute pancreatic conditions demanding surgical interference; on two occasions acute hæmorrhagic pancreatitis and once a large pancreatic abscess. The essential features of the disorder are best presented in short accounts of two cases.

ACUTE PANCREATITIS

A boy, aged 4 years, twenty-four hours previously, began to cry with severe upper abdominal pain. He vomited a few minutes later,

CHAPTER XXXIV

DISEASES OF THE RECTUM AND ANUS

THE DEVELOPMENT OF THE RECTUM AND ANUS

The hindgut ends blindly in a dilatation to which the embryologist applies the name of the '*entodermal cloaca*'. On the surface of the embryo, in a position corresponding to the entodermal cloaca, there is a depression of the epiblast, the *urogenital fossa*, and the membrane which separates the entodermal cloaca from the urogenital fossa is the *cloacal membrane*. About the end of the second month, the appearance of a septum, the *uro rectal fold*, divides the cloaca into two portions—an anterior or urogenital, and a posterior or rectal. That portion of the cloacal membrane which closes the rectal portion of the cloaca may be indicated by a special name—the *anal membrane*—and during the third month, a pit on its surface (the *proctodæum*) deepens so that the invaginating epiblast comes more closely into contact with the rectal portion of the cloaca.

About the beginning of the fourth month, the anal membrane ruptures, thus establishing a communication between the anal canal (proctodæum) and the rectum, in later life the position of the anal membrane is indicated by the *pecten of Stroud*, or *Hilton's white line*. The junction of the proctodæum with the cloaca does not occur at the actual extremity of the hindgut, for, caudal to the point of junction there is a further diverticulum, the projection of hindgut which is known as the *tailgut* or *post anal gut*. A portion of the tailgut which is in connection with the neurenteric canal ultimately forms the coccygeal or Luschka's gland, situated on the anterior surface of the coccyx, the remainder of it entirely disappears. In the event of an incomplete disappearance, the cul de sac may become the starting-point of sacro coccygeal cysts and tumours.

CONGENITAL ERRORS OF ANUS AND RECTUM

It has been estimated that anomalies of the rectum and anus are met with in a proportion of about 1 in 10 000 births. Certainly a small degree of occurrence, yet, in view of the gravity of certain of the errors, it is well to bear the possibility in mind. Collected statistics have shown that male children are more liable to these errors than

On Tuesday he seemed better ; the distention was less, but hiccough was troublesome. He was admitted to the Children's Hospital on Wednesday.

CONDITION ON EXAMINATION. The child looked acutely ill. The body surface had a slightly cyanotic appearance, and there was distinct jaundice. Temperature, 101.2° ; pulse, 128 ; respiration, 30 ; leucocyte count, 28,000 ; 86 per cent. of polymorphs ; the urine contained a quantity of acetone, no sugar or diastase was found, the adrenalin mydriatic test was negative. The abdomen was moderately distended, its upper and right half was occupied by a tender swelling which was continuous with the liver. Tenderness was most marked on pressure in the epigastrium, pain being also complained of on pressure below the last rib on the right side. Rectal examination was negative ; an effusion was found at the base of the right lung.

It was obvious that a localized inflammatory condition existed in the upper abdomen, but we were frankly at a loss to explain the exact diagnosis. A pancreatitis was suggested as a possible explanation.

Operation revealed a tense elastic swelling projecting above the lesser curvature of the stomach. The gastro-hepatic omentum which overlay the swelling was covered with a quantity of lymph. After isolating the area, the swelling was entered through the gastro-hepatic omentum. A large quantity of foetid pus escaped, and on mopping out the cavity, the abscess was found to have arisen in the pancreas. Several large portions of sloughed pancreatic tissue escaped from the wound. On account of the infection there was no opportunity to examine the other viscera. Local drainage was established, and a good recovery was ultimately made.

Bacteriological examination of the pus revealed a coliform organism, probably *B. Coli*.

This was an example of a case beginning as an acute pancreatitis, the infection eventually becoming localized into an abscess formation.

THE SPLEEN

The condition of splenic anæmia is improved, and sometimes cured, by splenectomy. In this disease, the spleen is apparently the *locus* in which a progressive destruction of red blood cells proceeds, and with removal of the organ, immediate benefit ensues.

Kaznelson,¹ believing that essential thrombo-cytopenic purpura is due to the thrombolytic action of the spleen, has advised splenectomy as a curative measure. The results reported have been encouraging.

¹ Kaznelson, I. : *Wien Klin. Wchnschr.*, 29, 1451, 1916.

once a week thereafter in order to prevent a recurrence of the contraction

If the atresia is a tubular one the operation of proctotomy is necessary. The procedure requires considerable care, and, if possible, a small speculum should be inserted so that the division can be carried out visibly. The incision should be confined to the posterior wall, as lateral incisions may be associated with troublesome bleeding, and an anterior incision may split upwards so as to involve the peritoneal reflection. After division, the lumen is gently stretched with the fingers until the narrowing has been overcome, subsequent stretching at regular intervals prevents recurrence of the contraction.

(b) **Occlusion by Membranes or Bands** A variety of different conditions may be grouped under this heading. Folds of skin may occlude the anal opening, abnormal arrangement of the mucous

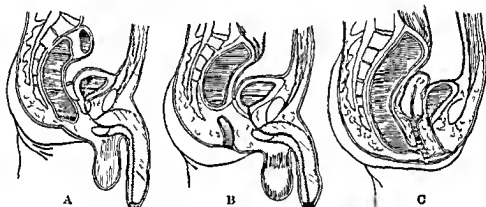


FIG 438—Varieties of Imperforate Anus

- A Imperforate anus with absence of the proctodæum
- B Imperforate anus in which the hindgut has failed to communicate with the proctodæum
- C Imperforate anus associated with a recto vaginal fistula

membrane may block the anal canal, a fibrous band may bridge the lumen, and in some cases there is a shelf like projection of fibrous tissue.

In cases of complete occlusion, a membranous diaphragm exists, because a communication has not been established between the proctodæum and the hindgut.

The various errors are apparent on examination, and digital or proctoscopic examination reveals the exact nature of the obstruction.

TREATMENT The simple and effective treatment is to excise the obstructing band or membrane. A single incision may be all that is required, but in complete occlusion the diaphragm is fully excised. The procedure is likely to be followed by considerable bleeding, but the hemorrhage is controlled by packing with gauze. When the bleeding is arrested the cure is completed by careful division with the fingers in order to stretch any atresia which may remain.

females, and the common experience has been that congenital errors in other parts frequently accompany the ano-rectal disorder.

THE IMPORTANCE OF THEIR RECOGNITION. Whenever an infant is born it should be the duty of the medical attendant to ascertain that the anus and rectum are patent. It has often happened that neglect of this precaution has led to the overlooking of an atresia until it was too late for surgical relief to be of any avail, and even after birth the symptoms of injury or straining during defæcation, errors of constipation, diarrhoea, prolapse, or abdominal distention should invariably suggest the necessity for digital or instrumental examination of the anus and rectum.

ETIOLOGY. Nothing definite is known regarding the cause of the error in development: foetal peritonitis, chorionic adhesions, and foetal enteritis have been suggested, while in many cases well-established claims have been advanced for a hereditary influence.

CLASSIFICATION. It is convenient to describe under separate headings—

1. Congenital malformations of the anus.
2. Congenital malformations of the rectum.

Congenital Malformations of the Anus

VARIETIES. The following are the common anal anomalies which come under the notice of the surgeon:—

- (a) Congenital narrowing of the anal canal.
- (b) Congenital occlusion of the anal canal by fibrous or membranous tissue, the occlusion being partial or complete.
- (c) Abnormal location of the anus.
- (d) Congenital absence of the anus.

Each of these errors calls for a brief special consideration.

(a) **Congenital Narrowing of the Anal Canal.** Soon after birth it is noticed that the infant has difficulty in defæcation, and that it cries and strains during the act. Examination with the fingers shows that the anus or the anal canal is congenitally narrowed; this may be caused by an annular stricture, or by one which is wider in extent, and therefore tubular in character. The error arises from the presence of fibrous tissue around the gut, and it is annular or tubular according to the extent and arrangement of the barrier.

SYMPTOMS. In addition to straining and crying during defæcation there may be incontinence of fæces, discharge of mucus and blood from the anus, or persistent constipation. Because the anus occupies its usual position, the explanation of the symptoms may be overlooked unless a digital examination is made.

TREATMENT. If the stricture is an annular one, simple division with the fingers is all that is required, a small bougie being inserted

birth, and, if not, the defect is soon made manifest by the signs of acute obstruction

Examination of the child's perineum yields a variety of impressions—a well marked median raphe may exist, so that there is no trace of the anus, on the other hand, if development has proceeded to some extent there may be a dimple or an ovoid depression. If the hind gut has developed normally, there may be a bulging in the perineum when the child strains or cries. Every case of this nature should be investigated in order to find out whether a recto vesical or recto vaginal fistula co exists

TREATMENT Immediate operation affords the only prospect of success, and the longer interference is delayed, the higher is the post operative mortality

The child must be kept as warm as possible during the operation, a local anæsthetic is used or a light general anæsthetic, the lithotomy position is the most convenient one for the operation

There are no conditions sufficiently urgent to demand the method of puncture with a trochar which is sometimes recommended. Open dissection is the only safe and reliable procedure. An incision is made in the middle line from the centre of the perineum backwards to the tip of the coccyx. This incision is gradually deepened, and two precautions must always be kept in mind while the dissection is being made—keep exactly in the middle line, and work as close to the sacrum as possible. In the male child it is a good plan to pass a urethral bougie, as this eliminates the danger of opening into the bladder. The bulging blind end of the rectum may be readily found, if it is not met with about an inch from the surface the child should be made to cry, when the bulging of the bowel may draw attention to its position. When the rectum is eventually defined its outline is gently separated until it is sufficiently loose to allow of its being brought down to the surface. The lumen is opened and the mucous edges are sutured to the skin, and if any trace of an external sphincter exists an attempt is made to unite it around the bowel. It is unnecessary to insert a rubber tube into the lumen of the bowel, and its presence may result in sloughing of the delicate mucous surface. The remainder of the skin wound is carefully sutured, and an antiseptic dressing is applied

If the lower end of the rectum cannot be found by a perineal dissection, it must be assumed that there is an associated error in the development of the hindgut, and in this event it is unwise to persist in a perineal exposure, as the peritoneum will almost certainly be opened, and the bladder or small intestine damaged. Instead, the original incision is prolonged backwards, and the coccyx and even the last piece of the sacrum are removed. This affords a considerable amount of additional space and, as the dissection is carried along the front of the sacrum the bowel wall is presently recognized. If it can be mobilized sufficiently, it is then brought down and sutured at the

Subsequent care is required to prevent recurrence of the contraction, and special attention is paid to the regulation of the bowels.

(c) **Abnormal Position of the Anus.** It sometimes happens that an error in the position of the original proctodæum results in the anus occupying an abnormal position. It may open in front of or behind the normal situation as a perineal or as a sacral anus. The more extreme degrees of abnormal situation, such as vaginal and urethral sites, are really types of fistula dependent on errors in the development of the rectum, and are described later. The true misplaced anus is therefore only found in the perineal and sacral regions, and it usually occupies the middle line. An anal depression may exist at the normal situation, or there may be an entire absence of any indication of its presence.

TREATMENT. If the abnormal opening is not far removed from the proper site it may be thought advisable to leave it alone, especially as the control is probably better than that which would result after operative interference. If the position is sufficiently abnormal to justify operation, an attempt should be made to transplant the anus and the anal canal into the correct position. Actually the procedure is not so formidable as it may sound.

An incision extending from the central point of the perineum to the tip of the coccyx is made in the midline; at the existing anus the incision diverges to include the opening with a surrounding collar of skin. By careful dissection, the existing anal canal is separated upwards until the lower end of the rectum is reached, and in the course of this dissection it is important to retain the internal sphincter by keeping some slight distance beyond the bowel wall. The separated anus and anal canal are now transported forwards or backwards, as the case may be, into the normal situation, and, as the external sphincter probably exists in its proper relation, an attempt should be made to insert the transplanted anus among its fibres. It now only remains to anchor and suture the anus in its new and proper position; a few deep catgut stitches are inserted, and the skin edges are carefully united with interrupted silkworm gut sutures. A tube should not be inserted into the anus. A few minims of tincture of opium are administered to prevent the bowel moving for four or five days, and at the end of that time the bowels are opened with medicine, and a small glycerine suppository is inserted into the anal canal before defecation occurs.

(d) **Congenital Absence of the Anus.** This is the error which is generally referred to when the term 'imperforate anus' is used. The actual absence of the anus depends upon an error in development of the proctodæum, but in actual fact there are many cases in which not only has the proctodæum failed to form, but the development of the hindgut has also been arrested. However, under this heading we only speak of those cases which arise from the pure proctodæal error. The condition is usually recognized at

TREATMENT The treatment of the error has been described in connection with imperforate anus. Removal of the coccyx or of the lower end of the sacrum is carried out to gain access to the bowel, and, if it cannot be brought down to the perineum, a sacral anus is made, while, in the more advanced type of error, a colostomy is necessary.

3 Membranous Occlusion of the Rectum

This represents the most favourable type of rectal maldevelopment. The anus and anal canal are well formed, and yet their communication with the lower end of the rectum is prevented by a membranous diaphragm. The symptoms and signs are similar to those of the other obstructions. Examination of the anus shows the presence of the obstruction, but the defect is of a soft yielding character, and when the child cries it bulges downwards upon the finger.

TREATMENT A cruciform incision is made into the centre of the diaphragm, and if necessary the redundant tissue is excised. There is comparatively little bleeding.

4 Recto-vesical, Recto-vaginal and Recto-urethral Fistulae

Abnormalities in the anatomy of the anus are often accompanied by fistulous communications between rectum, bladder, urethra, or vagina. The fistulous opening varies greatly in size, but it is generally a small tract which will barely admit a quill, occasionally the opening is surrounded by an imperfect sphincter.

Recto-vaginal Fistulae This is the most common error of the group. The normal anal opening is usually absent, but in the posterior vaginal wall there is a fistulous opening, through which faeces and flatus are expelled. As a rule the opening is at the lower end of the recto vaginal septum, occasionally it is in the upper end, in exceptional instances it is encountered in the vulvar region.

TREATMENT Unless signs of intestinal obstruction develop, it is better to leave the condition alone until the child is five or six years old. Earlier interference is apt to result in sloughing of the transplanted tissues.

The error is corrected by the operation of proctoplasty. A racket shaped incision is planned so that the head surrounds the fistula while the handle extends backwards towards the tip of the coccyx. The false anus, including its sphincter if present, is freed and dissected upwards for a distance of about 1 inch, it is then drawn backwards until the opening occupies the normal position, when it is sutured in place by a series of interrupted sutures.

Recto-vesical Fistula The rectum may open into the male or female bladder by a channel through which urine escapes into the rectum and meconium, faeces and flatus pass into the bladder. The error generally accompanies the condition of imperforate anus, and a diagnosis is made by the demonstration of faeces in the urine or urine

perineum, and in the event of this being impossible, a sacral anus will require to be made. If, after removal of the coccyx, the bowel cannot be isolated, a colostomy is the only choice that is left.

The mortality from the operation is high, and warmth and stimulation are required to tide the child over the shock which is inevitable. The bowel is kept quiet for three or four days after the operation by the administration of opium by the mouth; on the fourth day a laxative is given, and a glycerine suppository facilitates the result.

As the child grows older it should report from time to time in order that cicatricial contraction may be prevented by the introduction of a bougie.

Congenital Malformations of the Rectum

Errors in the development of the hindgut result in malformations of the rectum. These may exist, and yet the anus superficially appear normal, but in the great majority of cases, if the rectum is imperfectly developed, the anus and the anal canal share in the malformation.

The malformations of the rectum which are met with may be grouped under the following headings:—

1. Total absence of the rectum.
2. Atresia of the lower end of the rectum.
3. Membranous occlusion of the rectum.
4. Recto-vaginal, recto-urethral, and recto-vesical fistulae.

1. Total Absence of the Rectum

A few cases have been recorded in which the rectum has been replaced by a fibrous cord. The atresia may extend from the pelvic brim downwards towards the anus, which may or may not exist: above the atresia the bowel is distended into a saccular enlargement.

As a rule the anomaly is not recognized at birth unless there is an associated malformation of the anus. The absence of meconium, the abdominal distention, and the signs of acute obstruction eventually demonstrate that an obstruction exists. In certain cases a saccular tumour occupying the left flank can be made out on abdominal examination. If the anus is patent, examination through it will demonstrate the presence of the obstruction.

TREATMENT. The only treatment available is a colostomy, and, as it is impossible to bring the bowel down to the perineum, the artificial anus must necessarily be a permanent one.

2. Atresia of the lower end of the Rectum

This may be considered the same deformity as No. 1, but of a lesser degree, the termination of the rectum being replaced by a fibrous cord, or ending completely in a distinct pouch. In the majority of cases there is an imperforate condition of the anus.

POLYPUS OF RECTUM

Rectal polypi are comparatively frequent in childhood. They are benign, pedunculated tumours growing from the posterior wall of the bowel, soft in consistency, single, the size of a cherry, and of a dark red colour.

In their beginnings, the tumours are sessile, but, as the result of the downward drag to which they are constantly being submitted, they become pedunculated. The attachment of the pedicle is usually $1\frac{1}{2}$ to 2 inches above the anal margin.

ETIOLOGY We have no knowledge of the origin of the condition, the affection is specially frequent between the second and fourth years, and is often associated with prolapse of the rectal wall.

SYMPTOMS AND PHYSICAL SIGNS Painful defæcation, straining at stool, a frequent desire to go to stool, and the presence of blood and mucus in the stools are the usual features. This group of symptoms is usually ascribed by the parents to hæmorrhoids, but examination of the bowel makes the diagnosis clear. The pedunculated tumour is recognized, it bleeds freely when touched, and it may be possible to bring it down so that it projects from the anus. Care must be exercised in this stage of the examination in case rupture of the pedicle should occur—an event which may be followed by alarming hæmorrhage. If a satisfactory examination cannot be made by the fingers, a speculum should be used.

TREATMENT Removal of the polypus is easily effected. The sphincter is dilated under anæsthesia, the pedicle is ligatured close to the wall of the rectum, and the tumour is removed. To prevent the ligature slipping the pedicle should be transfixed with a round needle, and an interlacing knot used. Dilation of the sphincter is particularly important, as a contracted sphincter may mask a copious hæmorrhage.

FISSURE OF THE ANUS

An anal fissure is a small intra sphincteric ulcer hidden in the folds of the anus and usually situated on the posterior wall. The condition is comparatively frequent in babies at the time when they first begin to pass a formed stool. The stretching of the delicate mucous membrane results in a slight tear, and the continual irritation to which the part is subjected delays healing so that an ulcer develops.

SYMPTOMS The characteristic feature is pain after defæcation. The child cries bitterly, and for a time there may be difficulty in arriving at an explanation of the distress. Constipation may be an initial feature, later it becomes voluntary on account of the pain which the motion induces. The stool may be stained with fresh blood.

Anal fissure is an oft quoted example of a sensory muscular reflex. The exposure of the sensory nerve filaments on the ulcer surface

in the faeces. Infection of the respective mucous surfaces always accompanies the disorder.

TREATMENT. As soon as the condition is recognized a colostomy should be performed in order to forestall infection of the urinary tract. The lower bowel is then cleansed by lavage, and the child voids urine by the rectum without discomfort.

When the patient is about two years old, the fistulous tract is exposed from the perineum, the edges are freshened, and the opening closed. When the success of this stage is assured the colostomy is closed. If the recto-vesical opening is high, the plastic operation may have to be performed through the abdomen.

Recto-urethral Fistulæ. Malformations of this type are usually



FIG. 439.—Tumour of the Vulva.

A pedunculated myxo-fibromatous tumour is projecting from the anterior wall of the vagina

encountered in male children. The fistulous opening is generally located in the membranous portion of the urethra, and the communication is a very small one.

TREATMENT. If an imperforate anus exists, as it almost certainly does, the correction of this error is often sufficient to allow the fistulous opening to close. In the event of the fistula persisting a plastic operation will become necessary.

Rare Fistulæ. A few cases have been reported in which the rectum communicated with the cervix uteri, and Ballingall met with an example in which a communication existed between the rectum and the fundus of the uterus.

Examples of recto-ureteral fistula are associated with congenital absence of the bladder, so that the rectum performs a double function. Cases of this nature are better left alone.

- (5) The increased intra abdominal pressure which accompanies prolonged straining at stool in a sitting position, or whooping cough, or phimosis

In the ordinary type of case the etiological sequence is somewhat as follows. For some reason the child loses weight and becomes generally debilitated, the fat around the bowel is diminished, while the supporting muscular structures are weakened—in fact, the essential perirectal supports are interfered with. Constipation now ensues, and in the efforts to relieve this the mucous lining becomes loosened in its attachment to the underlying submucosa. A partial prolapse now begins, and its presence in the interior of the bowel is but a further stimulus to those forces which exaggerate the prolapse.

Mild degrees of prolapse invariably accompany rectal polypi, and here the mechanical influence is obvious. The most extreme errors



FIG. 440.—Prolapse of the Rectum occurring in a boy 8 months old

occur in association with errors of the nervous system, such as spina bifida and the paralysis of Potts' disease.

SYMPTOMS AND SIGNS. In slight cases a rosette of mucous membrane protrudes from the anus subsequent to defaecation. In severe cases the entire rectum is prolapsed as an elongated tube of mucous membrane curved so that it is convex posteriorly. A recent prolapse is of a violet red colour but if it remains, it becomes swollen and so congested that it bleeds, while areas of ulceration appear over its surface.

It is evident that in an extensive rectal prolapse there are two portions of the rectal tube with their serous coats in contact, so that a potential sac exists into which small intestine may herniate (*a hydrocele*).

If a prolapse is permitted to remain unreduced for any length of time there is pain, hæmorrhage, ulceration, and infection—a group of features which may imperil the child's existence.

causes a reflex contraction of the related muscular groups; there is therefore intense spasmodic contraction of the anal sphincter, and it may be of the vesical sphincter; the retention of urine, which so often complicates fissure, is explained in this way. Sometimes pain is referred to the hip and knee, and there may be muscular contraction of the lower limbs.

The hypertrophy of the anal sphincter, which results from the constant overaction of the muscle, is said to be the explanation of the feature that the pain, at first temporary and occurring only after the passage of the stool, ultimately becomes constant.

EXAMINATION. In young children it is essential to carry out a careful examination under light anæsthesia. The sphincter is gently dilated, and the ulcer localized.

TREATMENT. The first necessity is to relieve the constipation, and this is best done by the administration of liquorice.

Local Treatment. Good results may be obtained by applying a 10 per cent. solution of silver nitrate to the fissure, or by the use of a 5 per cent. cocaine ointment. If these measures fail, the sphincter should be stretched and the base of the ulcer divided with a sharp knife—this affords immediate relief.

After operation the child should be kept in bed on light diet for three or four days.

PROLAPSE OF THE RECTUM

Prolapse of the rectum—a protrusion of the lining of the bowel through the anus—is a common event in ill-nourished and debilitated children. The term ‘procidencia’ is sometimes used to convey the same meaning.

VARIETIES. Various descriptive terms are used in different varieties of the disease. A prolapse is ‘partial’ when the mucous lining of the anal canal is prolapsed, it is ‘complete’ when there is a protrusion of the entire rectum wall. The terms anal, rectal and sigmoidal are used to indicate the situation from which the prolapse has proceeded.

ETIOLOGY. The influences which play a part in the production of prolapse may be summarized as—

- (1) Tumours attached to the mucosa which are grasped in the contraction of the gut and so loosen the attachment of the mucous membrane to the bowel wall.
- (2) Excessive contraction of the bowel wall, leading to a relaxation of the submucous tissue and an imperfect support of the mucous lining.
- (3) Weakening of the peri-anal and peri-rectal attachments (the sphincter, the muscles, the ligaments, and the surrounding fat).
- (4) Imperfect support of the rectum during the period prior to the acquisition of the full sacral curve.

CONSERVATIVE TREATMENT

Regular soft motions are secured, liquorice being a peculiarly valuable drug in this connection. The rectum is irrigated night and morning with an astringent lotion such as alum solution (20 grains to the pint), or infusion of quassia. The application should be made as cold as possible. The child should be taught to defæcate either in the recumbent position or on its side with the hips elevated, so as to diminish pressure upon the lower bowel. Afterwards a pyramidal-shaped pad of pleated gauze is fitted so that its apex rests upon the anus, this is worn constantly, being retained in place by broad bands of adhesive plaster which at the same time draw the buttocks together.

This line of treatment must be pursued for weeks or months, as may be necessary with the return of tone to the various muscles of the sphincteric region the treatment may be abandoned.

Injection Treatment. Moderate degrees of prolapse have been successfully treated by the injection into a circular series of points in the submucous tissue, of quinine urea solution (10 per cent). Carbolic acid, glycerine and olive oil in equal parts have been used for a similar purpose, but this solution is apt to be followed by sloughing. The success of the treatment depends upon the formation of scar tissue and subsequent contraction.

Operation. A great variety of measures has been suggested, but only those of proved merit are described. Operation is indicated if the prolapse has existed for a long time, if the sphincter has lost its tonicity, and if reduction cannot be maintained. Many operations which are suitable for adults cannot be used in children on account of their severity—the simpler measures are generally the best.

A Linear Cauterization. The protruding prolapse is kept taut by passing a suture through its apex, while with a Paquelin or an electric cautery a series of dry linear burns, $\frac{1}{2}$ inch apart are made in the long axis of the gut, completely round the circumference. The burn should be carried almost through the mucosa, but, if the prolapse is so large that a peritoneal reflection exists in the wall, care must be exercised in case the peritoneum is perforated and peritonitis ensues. The perianal skin and sphincter are cauterized at four equidistant points around the anus, the tissues being penetrated for about $\frac{1}{2}$ inch. The prolapse is now reduced, and a wide strip of vaselined gauze is passed into the lumen of the bowel so as to prevent the raw surfaces coming into contact. A return of the prolapse is subsequently prevented by the use of a pyramidal pad.

B Linear Excision of Mucosa.—Three or four strips of mucosa, each about $\frac{1}{2}$ inch wide, are removed at equidistant points around the prolapse the edges are united by continuous catgut sutures applied on the lock fashion. This method is apt to be followed by con-

DIAGNOSIS. Prolapse is apt to be confused with (1) rectal polypus (2) intussusception which has protruded from the anus. In both of these conditions the examining finger can be passed between the tumour and the rectal wall.

PROGNOSIS. Under efficient treatment, if the condition is recognized and dealt with early, a cure should be obtained by conservative or simple operative measures. In neglected cases the weakening of



FIG. 441.—Intussusception projecting from Anus and thus closely simulating the condition of simple Prolapse (Baby 6 months old).

the sphincter and related muscles increases the difficulties of obtaining a complete cure.

TREATMENT

In a certain proportion of cases there is a tendency towards spontaneous cure, and, if the prolapse is kept reduced, and the obvious etiological influences are corrected, good results may be obtained.

The cases which come under this group are indicated by certain characters—the prolapse is not extensive, when reduction is carried out there is no immediate relapse, the sphincter muscles show a certain amount of tone. Under these conditions the case may be considered as a suitable one for conservative measures.

PERI-ANAL AND ISCHIO-RECTAL ABSCESSSES

Acute Ischio-rectal and Peri-anal Abscesses are rare in children. The entrance of the infection is through a pre existing fissure or wound of the ano rectal mucosa.

Chronic Peri-anal Abscesses are comparatively common. They are usually multiple. McQuigg suggested that they are really small implantation cysts which have become infected. In our experience, many cases of this nature are tuberculous in origin—tubercle bacilli are excreted by the fæces, they are implanted at various points of the peri anal surface so that points of chronic abscess formation result.

Excision of each individual point is the most satisfactory method of treatment.

siderable hæmorrhage, and for twenty-four hours subsequent to the operation, a dressed tube should be kept in place.

C. The Sacral Stitch Method. This method consists in fixing the posterior wall of the rectum to the sacrum by a transverse suture; it is generally associated with Ekehorn's name.

The prolapsed rectum having been replaced and kept in position by the forefinger of the left hand, a moderate-sized needle on a handle is passed through the skin to one side of the extremity of the sacrum. It is carried through the soft tissues till it pierces the rectum and meets the finger, which guides it to the anus. The needle is now threaded with stout silk or silkworm gut, the thread carrying a length of capillary rubber tubing about 1 inch long. One end of the thread is drawn back with the needle; a similar procedure brings the other end out at the same level on the other side of the sacrum, the portion threaded with rubber remaining within the bowel. The two ends of the ligature are now tied together over the skin, a length of capillary tubing being again used to prevent cutting.

A modification of this method was suggested and followed by Tuttle—the needle is carried through the posterior wall of the rectum without the mucous lining being involved. Having traversed the sub-mucous tissues of the bowel the needle is brought out again at the same level, but at the other side of the coccyx, and the two ends are united over a pad of gauze. Tuttle claimed that his method is a more aseptic procedure than that practised by Ekehorn.

In our own practice we have found the method of sacral stitching on Ekehorn's plan to be the most satisfactory. The stitch should be inserted at a level within the bowel corresponding to the distance to which the prolapse descends; in this way the point of fixation is at, or immediately above, the level of the inverted section.

D. Anal Suture. Kellogg Speed sutures the anus with a stout silk thread in a curved needle, beginning near the median raphe in front and passing the suture completely around the anus. It is then drawn tight and tied, so that not even a grooved director can be inserted into the anal canal.

The child remains in bed and is kept upon a diet which leaves as little residue as possible. A few minims of tincture of opium are given each day. At the end of a week the purse-string is cut; the child remains in bed for a week longer. Magnesia is given by the mouth to keep the motions soft, and defæcation is carried out in the supine position.

Many other methods have been used. Spitzzy practised the injection of paraffin on each side of the rectal wall so that two pencil-like splints are formed. This method is not to be recommended because of the irritation which the paraffin eventually produces.

Amputation of the prolapse is rarely advisable in childhood. The operation is one of considerable severity, and the results are no better than those obtained by simpler and safer methods.

PERI-ANAL AND ISCHIO-RECTAL ABSCESES

Acute Ischio-rectal and Peri-anal Abscesses are rare in children. The entrance of the infection is through a pre-existing fissure or wound of the ano-rectal mucosa.

Chronic Peri-anal Abscesses are comparatively common. They are usually multiple. McQuigg suggested that they are really small implantation-cysts which have become infected. In our experience, many cases of this nature are tuberculous in origin—tubercle bacilli are excreted by the faeces, they are implanted at various points of the peri-anal surface so that points of chronic abscess formation result.

Excision of each individual point is the most satisfactory method of treatment.

CHAPTER XXXV

SURGERY OF THE GENITO-URINARY SYSTEM

I. DISEASES OF THE KIDNEY

THE DEVELOPMENT OF THE KIDNEY

The metanephros or permanent kidney develops in relation to certain budlike diverticula which sprout from the lower ends of the Wolffian ducts. The buds extend upwards and backwards behind the Wolffian bodies (mesonephros), and, as they lengthen, their blind ends subdivide and the mesenchyme arranges itself around each subdivision so as to form a series of more or less separate lobules surrounded by a common capsule.

Originally the mesenchyme is composed of multiple cellular condensations—at first solid, but later hollowed into a tubular and somewhat sigmoid arrangement; this system becomes the *secretory tubules*. The *collecting tubules* are formed by a continuous process of dichotomous budding from the primary divisions of the original pelvis, and an outer zone of the original mesenchyme provides the connective tissue framework and capsule of the organ. As the secretory tubules develop, they come into contact with branches of the renal vessels, and the blind end of the tubule invaginates itself around the vessel so as to constitute a Bowman's capsule with its glomerulus.

Changes in Position of the Kidney. The original renal buds lie at the level of the second sacral vertebra, gradually migrate upwards to the level of the third lumbar vertebra, and in doing so, undergo a rotation so that the hila look inwards instead of forwards, the position which they originally occupied.

The process of upward migration with rotation continues until the end of the second month of foetal life, when the centre of the kidney mass reaches its permanent position opposite the first lumbar vertebra, and the rotation becomes complete.

It is only after the kidney has come to rest in its final position that its permanent blood supply is acquired; vessels grow out from the aorta and vena cava and vascularize the developing tissue.

The lower end of the ureter undergoes changes of position. Originally the opening is into the Wolffian duct above the communication of the latter with the uro-genital sinus; later an independent opening is acquired, and at the same time the ureter undergoes a rotation so that it lies to the outer side of the Wolffian duct (vas deferens).

A knowledge of these embryological details is necessary if we are to understand the various abnormalities in form, position, and blood supply of the kidneys and ureters

The Secretion of Urine We have no exact knowledge in regard to the time at which the kidneys first begin to secrete urine. Some authorities state that the function commences about the third month, others believe that no urine is secreted until birth unless there is such disease of the placenta that the excretory functions of that organ are interfered with

ABNORMALITIES OF THE KIDNEY

The following classification embraces the various renal abnormalities —

Persistence of fetal lobulation

Horse shoe kidney

Unilateral fused kidney

Pelvic kidney

Congenital absence of one kidney

Persistence of Fetal Lobulation

This abnormality is of no clinical significance. Kuster and Wagner state that kidneys of this type are more vulnerable to disease, and particularly to tuberculosis

Horse-shoe Kidney If the fetal kidneys in the course of their ascent come into contact with each other,

partial coalescence may occur, and if the continuity is in the form of a bar or commissure a horse shoe kidney results. The connecting isthmus may embrace the capsule only, so that the junction is a fibrous cord; more frequently it is a band of renal parenchyma, normal in structure, and provided with its own artery.

The communication is usually between the lower poles—median and upper bars are very uncommon—and the isthmus overlies the aorta. Kidneys deformed in this way are usually arrested in their ascent so that the lower border may lie over the pelvic brim.

Special interest attaches to the ureters and pelves. The existence of the isthmus interferes with the process of rotation, the result being that the hilum faces anteriorly. The pelves are frequently divided and

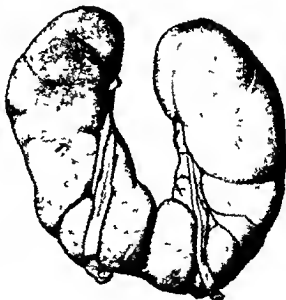


FIG. 442.—Horse shoe Kidney
specimen obtained from child 7 years old who died from acute pneumonia

complex, and the ureters in crossing the bar may be so angled as to produce obstructive changes. The relations of the pelves and ureters to the renal vessels are usually anomalous and rarely alike in two cases.

The condition is a surgical curiosity. Apart from the possibility of hydronephrosis as the result of pressure upon the ureters it gives rise to no feature of clinical significance. In one instance which came under our observation, the bar simulated an abdominal tumour.

Unilateral Fused Kidney. The unilateral fused kidney is a condition of great clinical interest and importance, and as the ureters in these cases open normally into the bladder, the true state of affairs may be missed even after a careful cystoscopic examination.

The error apparently arises from fusion of the embryonic kidney tissue at some period after the development of the Wolffian buds. The amount of renal tissue present is usually less than that of two normal kidneys. The arrangement generally is that one kidney is normally situated, but its lower pole is fused with the second organ, which lies immediately below. There would appear to be no rotation in the process of transposition, and the hilum remains directed to the same side as would have been the case had the organ remained in its normal position. The ureters arise from separate well-defined pelves lying superimposed. The ureter from the upper pelvis passes down to enter the same side of the bladder, that from the lower crosses the midline to enter the bladder on the opposite side.

The arrangement of the blood-vessels is anomalous. As a rule two vessels pass from the aorta to the upper organ; the supply of the lower portion is irregular, the vessels may spring from the internal iliac arteries.

It is easy to appreciate circumstances of great clinical importance which may proceed from this abnormality.

Radiography, the passage of opaque bougies, and pyelography, make the diagnosis clear.

Pelvic Kidney. The abnormality of pelvic kidney results from failure of the organ to ascend into the loin. It remains as a pelvic organ, occupying a position in the hollow of the sacrum. Girard believed that the acquisition of the blood supply at a too early period explained the error, the vessel remaining short and so retaining the organ in its pelvic position.

As a rule the kidney of the opposite side ascends to its normal position, but Polk has recorded a case in which the pelvic organ existed as a fusion of both kidneys.

Congenital Absence of the Kidney. This abnormality has frequently been described. The coincidence of other congenital malformations, especially of the genital tract, is mentioned by all writers on the subject. The female may show a bicornuate uterus, in the male the testis of the corresponding side is often absent.

The homolateral adrenal gland is generally present. In two instances which we have seen, the ureter existed as a tubular structure distended with mucus, forming a swelling of such a size that an abdominal tumour was suspected.

TUBERCULOUS INFECTIONS OF KIDNEY AND URETER

Examples of renal tuberculosis are frequently met with in the wards of a children's hospital. The idea is often expressed that the disease is uncommon, but this has not been our experience, our impression is that the kidney is the most frequent site of genito urinary tuberculosis.

ETIOLOGY. The disease affects girls more frequently than boys in a proportion which is estimated to be about ten to one. Such a disproportionate incidence must have some explanation, and we believe it is to be found in the higher degree of frequency with which the female child is affected by pyelitis and minor types of renal infection. The preceding simple infection is undoubtedly a predisposing factor in the later development of the tuberculous disease.

A pre-existing tuberculous infection exists in some part of the body, for the organism is invariably carried to the kidney by the blood stream, yet the sufferer is one who may show no other obvious local evidence of the disease—in fact (and the observation is both interesting and difficult to explain), renal tuberculosis is uncommon when multiple tuberculous lesions exist. Examples of an ascending ureteral infection are exceedingly rare in childhood, the event is sometimes met with in the male child as in the adult, where disease of the epididymus extends to the base of the bladder and ultimately spreads to the kidneys *via* the ureter.

One is sometimes tempted to believe that the kidney may be infected by direct spread from diseased adjacent glands, but it is difficult to obtain confirmation upon this point.

PATHOLOGY. In established cases of the disease, the pathology takes a variety of forms. The *fibro caseous* or *cavernous* is the type most frequently met with. In this example the kidney surface may be smooth and to all appearance healthy, or it may present a number of scattered follicles each adherent to the overlying capsule. On section caseous nodules are found to exist at the junction of medulla and cortex. They appear first at the upper and lower poles, but soon the complete extent of the organ is involved. Each nodule consists of a centre of caseous material, a surrounding layer of granulation tissue, and a limiting fibrous capsule. From the central focus, secondary tubercles extend along the blood-vessels until the subcapsular tissues are reached.

The distribution of the disease is on a somewhat wedge shaped basis, suggesting that it is related originally to the infection of a lobular artery. Individual nodules may eventually rupture into the pelvis.

of the kidney, and so leave a cavity which is lined with tuberculous granulation tissue.

Secondary infection is sooner or later inevitable, and with its appearance the picture alters—the tuberculous infection becomes more widely extended, and phosphatic calculi may form in the pelvis or in the interior of the original cavities. Infection and blocking of the ureter is followed by the development of a tuberculous pyonephrosis.

While this is the common variety met with in children, other types are occasionally described. There is an *ulcerative* form in which the original tubercles develop in the submucous tissue covering the renal papillæ: caseation and confluence of the tubercles form ulcers, which ultimately invade and destroy the pyramids.

We have seen several examples of a *fibrous* variety, in which the kidney shows a diffuse interstitial sclerosis with scattered tubercles. There is little or no caseation, and the renal pelvis is occupied by a mass of fibrous tissue and fat.

It is fortunate that the disease is generally unilateral; bilateral infections are met with in neglected cases, and in association with miliary tuberculosis.

CLINICAL FEATURES. The symptomatology of the disease is a varied one. As a rule frequency of micturition, the evidence of cystitis, is the event which first draws attention to the condition. Dysuria and incontinence of urine may accom-

pany the frequency. In several cases an attack of hæmaturia has been the first clinical manifestation. Together with the local signs there is a loss in weight with a decline in the general health, and an evening rise of temperature is a frequent accompaniment. It is only in advanced cases that pain in the loin is complained of.

EXAMINATION. The frequency of micturition calls for an examination of the urine, which is then found to be acid and to contain pus cells and generally a few red blood corpuscles. Examination of the centrifugal deposit may reveal the presence of tubercle bacilli, but a negative finding in this respect must not be regarded as excluding the disease. If the other evidences are suspicious, a guinea-pig should be inoculated with the deposit from the suspected fluid.

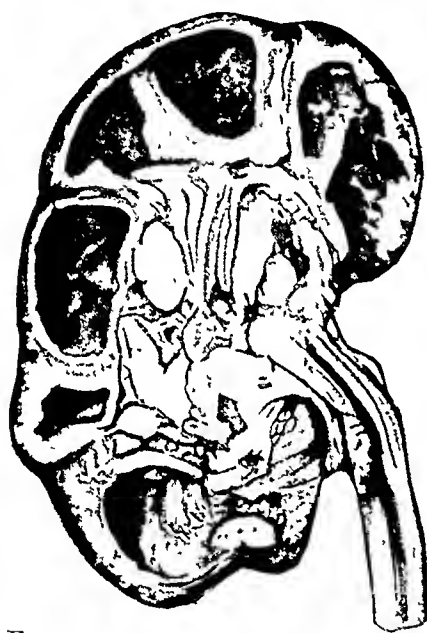


FIG. 443.—Tuberculous Disease of Kidney (Girl 5 years old).

The disease led to blocking of the ureter, and a tuberculous hydronephrosis has developed

Palpation of the kidneys may reveal a characteristically irregular enlargement of one or both of the organs, the affected kidney being tender to touch

X ray examination may yield helpful information, for a tuberculous kidney throws a denser shadow than that afforded by a healthy one

Cystoscopic investigation reveals a chronic cystitis, the infection being most marked in the trigone and around the opening of the ureter which is in connection with the infected kidney. It may be possible to demonstrate that pus is being discharged from one or both ureters, and the intra muscular injection of 5 to 10 c c of 0.4 per cent indigo carmine is associated with a lengthening of the time period before the pigment is produced by the diseased kidney. In some cases the ureter opening on the affected side may shew an 'indrawn' appearance

Ureteral catheterization supplies information regarding the urine supplied by each kidney, but pyelography is to be avoided, as the manipulation may act as a stimulus to the infection

In a complete investigation the observer will find that the blood urea content is increased, while the urea percentage in the urine is diminished. There is no increase in the output of urine creatinin after the intra venous injection of 0.1 grammes of the drug

DIAGNOSIS The diagnosis necessarily includes two considerations —

(1) The specific nature of the disease

(2) The distribution of the disease—whether unilateral or bilateral

(1) *The Specific Nature of the Disease* An intractable cystitis should arouse suspicions of a tuberculous origin, and a detailed examination of the urine may demonstrate the existence of tubercle bacilli. Radiographic and cystoscopic examination afford confirmatory evidence. In doubtful cases Ludham Green advised the injection of a single large dose of old tuberculin—a positive case responds by developing local pain, increase of pus in the urine, and hæmaturia. The method has obvious disadvantages, and it is replaced by more reliable and less dangerous methods

(2) *The Distribution of the Disease* The seat of the disease is established by palpation, X ray examination, cystoscopic investigation and the examination of the urine obtained by ureteral catheter. If doubt should still exist regarding the condition of the opposite kidney, the operation may be planned in such a way as to bring the organ under direct observation—this point is alluded to later in dealing with the question of treatment

Differential Diagnosis Tuberculosis of the kidney may be mistaken for pyelitis and pyelo nephritis, renal calculus, tumour of the kidney, and chronic cystitis

Pyelitis and Pyelo-nephritis. The chronic form of this disease may simulate tuberculosis so closely that a distinction can only be drawn when a bacteriological examination is made of the urinary deposit. The urgent symptoms of acute pyelitis are sufficient to distinguish it.

Renal Calculi and Tumours. These are recognized by their distinctive characters as demonstrated in the course of the routine examination.

Chronic Cystitis. Primary cystitis is an uncommon event in the child, but when it occurs, as it may in association with stone or congenital fistulæ, the nature of the condition is established by cystoscopic examination.

PROGNOSIS. In the vast majority of cases, renal tuberculosis ends in complete destruction of the affected organ. The process may take several years, but the end is almost inevitable, and in the meantime the diseased kidney remains as a constant source of infection both for the lower urinary tract and for the body generally. Without nephrectomy the tendency is to progress to a fatal issue, although there may be long intervals during which there is comparative relief from symptoms. On the other hand, a unilateral disease, if recognized early and treated by nephrectomy, is one of the most favourable forms of tuberculous disease. Even when ureter and bladder have become infected, removal of the kidney is followed by disappearance of the disease from the other organs.

TREATMENT. There is now almost universal acceptance of the view that, if conditions are satisfactory, cases of this nature should be treated by nephrectomy.

It is fortunate that in some 90 per cent. of the early cases, the disease is unilateral, and moreover that in children almost all the cases are due to blood infection, in which the kidney is the first organ of the genito-urinary system to be attacked. In view of these accepted facts, and considering the statement already made that spontaneous cure is almost unknown, it is obvious that operation offers the best prospects of success.

The question of operative treatment may be best summarized under headings of indications and contra-indications.

Operation is indicated—

- A. When the disease is unilateral.
- B. When one kidney is extensively involved, the other being but slightly infected. In this event the removal of the more advanced focus may prolong life for several years.

Operation is contra-indicated—

- A. When both kidneys are severely involved.
- B. When there is such extensive general infection that it is obvious that the patient has only a few months to live.

Operation. If it has been definitely established that the opposite

kidney is healthy, the diseased kidney is removed through the loin it is particularly important not to incise the kidney during removal, in case infection of the wound should ensue

If, as may happen under certain conditions, cystoscopy and ureteral catheterization have been impossible, the affected kidney should be exposed by the abdominal route, and the opportunity is taken to investigate the condition of the other kidney by palpation

PYELITIS AND PYELONEPHRITIS

Reference has frequently been made in connection with abdominal disease to the important part which infections of the upper urinary tract play in the questions of diagnosis, and therefore, while pyelitis and pyelonephritis rarely call for surgical interference, they are so intimately related to various surgical questions that a brief consideration of their more important features is essential

Pyelitis is the most frequent of the various inflammatory affections of the urinary tract. It is the result of the infection of the pelvis of the kidney by the bacillus coli. In the early stages of the disease this organism is the only one which is present in the urine, in late and advanced cases streptococci and staphylococci exist, but these are superadded and secondary

ETIOLOGY It is probable that the infection reaches the renal pelvis by various routes. The organism may extend from the surface via the bladder and the ureter, or via the peri ureteral lymphatics. The existence of this route is said to explain the higher proportion of cases which occur in girls owing to the relative patency of the urethra in the female. Another route is by direct extension from the overlying colon, and the greater frequency with which the left pelvis is affected is said to be explained on anatomical grounds, because on the right side the kidney is related to the duodenum. In a few cases the infection is carried by the blood stream

Secondary Factors Female children are more frequently affected than males in a proportion of about four to one. The reason for this has been stated, and an explanation for the supposed preponderance of left sided infection has also been suggested. The disease is most frequent in the first two years of life. Any debilitating disease has a predisposing influence, and cold has a similar effect. Constipation is a factor in encouraging direct infection from the overlying bowel

PATHOLOGY The disease begins as an acute catarrh of the renal pelvis, the infection spreading upwards along the calyces, and some degree of pyelonephritis probably complicates every case of pyelitis of any severity. Pus cells and desquamated epithelium pass from the catarrhal surface into the interior of the pelvis and there is congestion of the related vessels. In severe cases the ureter opening may become blocked as a result of the oedema and debris accumulation

SYMPTOMS AND SIGNS. In many cases the symptoms are so slight that the condition passes unnoticed unless examination of the urine has been carried out.

A small proportion of the cases begin with malaise, frequency of micturition or incontinence, but as a general rule the onset is sudden. The child is drowsy and irritable, general body pain is complained of, there may be vomiting, a rigor generally occurs in severe cases, and when the temperature is taken it is found to be somewhere in the neighbourhood of 103° to 104° .

Local evidences may be difficult to elicit. Colicky pains are complained of in the upper abdomen, and there is tenderness on deep pressure on one or other side of the midline immediately above the umbilicus; the affected kidney may be enlarged and tender on pressure. A considerable degree of leucocytosis is usually present.

The urine has characteristic features. It is opalescent in appearance and acid in reaction. If allowed to stand for some time, a deposit of pus and organisms forms. If a drop of fluid is taken from the middle of a urine glass and examined microscopically, pus cells and colour bacilli are found. The urine contains a relatively small amount of albumen.

DIAGNOSIS. A female child who appears to be intensely ill, and who shows a high temperature and yet on local examination reveals comparatively little to account for the symptoms, is probably suffering from pyelitis. The diagnosis is confirmed when pus and *B. coli* are discovered in the urine.

Two sources of error in the examination have to be borne in mind. Several days may elapse before the pus makes its appearance, and in unilateral examples of the disease the ureters may become blocked from time to time so that the pus temporarily disappears.

One of the surgical interests of the disease is the liability which there is to confuse it with acute abdominal conditions. The abdominal tenderness, the vomiting and the fever sometimes give rise to difficulty, but the absence of rigidity and the characteristic findings in the urine are sufficient to distinguish the condition.

A congenital hydronephrosis which has become infected simulates a pyelitis, and of course the two diseases are closely related, but the infinitely more serious hydronephrosis is distinguished by the large size of the kidneys, the relatively great amount of urine which is passed, and the associated hypertrophied condition of the urinary bladder.

THE PROGNOSIS is uniformly good if the disease is recognized and treated at an early stage. Neglected cases may pass into pyelonephritis or pyonephrosis, or the weakness which accompanies the urinary infection may be followed by a fatal incurrent disease such as pneumonia.

TREATMENT. The treatment is essentially medical, and fortunately the disease is amenable to therapeutic measures. Large amounts

of bland fluids are given by mouth, while salines are administered per rectum or subcutaneously. A regular action of the bowel is assured by means of calomel and sodium phosphite. The urine is rendered alkaline by the administration of large doses of sodium citrate (20 grains t i d) combined with bicarbonate of soda. After the urine has remained alkaline for a week, and the temperature during that time has subsided, the reaction of the urine may be changed by the use of acid sodium phosphate and urotropin. In intractable cases sera and vaccines may be beneficial.

Pyelonephritis The general septic infection of the kidney which the term pyelonephritis expresses may result from a blood infection of the organ such as one finds in association with septicæmia and scarlet fever, or it may be the result of extension to the kidney from an original pyelitis infection.

The kidneys are enlarged, soft, and of a purplish red appearance. Numerous points of infection are scattered throughout their substance, these areas are hæmorrhagic at first and afterwards purulent. The child is intensely ill, the amount of urine passed is small in amount, and contains blood and pus with a considerable quantity of albumen. There is usually hyperpyrexia, though in the most severe examples the temperature may be subnormal.

TREATMENT In severe cases medical measures such as alkalinization of the urine are usually unavailing. Surgical means are worth a trial, they consist in exposure of the kidney from the loin, separation of the capsule, free incision of the kidney substance on the convex border into the pelvis, and drainage on to the loin.

Decapsulation of the kidney in Bright's Disease The benefits derived from Ediboh's operation are so great as to justify decapsulation of the kidney in cases of chronic nephritis which do not improve under medical treatment. The results of catheterization of the ureters show that after operation the kidney which has been stripped functions better than the other. It is advisable in all cases to operate on both kidneys, because, while stripping one kidney often relieves the symptoms for a time, the albuminuria continues, whereas the double operation offers a prospect of cure. There is no advantage, but rather the reverse in decapsulating both kidneys at the same time. The second operation should be postponed until after recovery from the first.

TUMOURS OF THE KIDNEY

The range of varieties of renal tumour formation in the child is a limited one. Simple tumours, such as fibroma, adenoma and angioma occur, but they are so rare that their interest is a minor one. The tumours which occur with any degree of frequency are malignant in type. The records of the Edinburgh Children's Hospital for the past fifteen years have been reviewed, with the result that the *adeno*

myo-sarcoma is found to be the most common variety: about 95 per cent. are of this nature. The other varieties can only be spoken of as rare exceptions—they were the sarcomata and hypernephromata.

The frequency with which the *adeno-sarcoma* type of tumour occurs in childhood justifies a short description of this interesting disease.

Adeno-myo-sarcoma (Embryomata) of the Kidney.

The descriptive term applied to the tumour is misleading, for it seems paradoxical to speak of epithelial and sarcomatous tissue in connection with the same tumour. The term *embryoma* is to be preferred. When one speaks of mixed tumours of the kidney as occurring in infancy, it is this type of affection which is meant.

PATHOLOGY

The affected kidney is enlarged to a varying degree. The surface



FIG. 444.—Adeno-sarcoma of Kidney. Appearance on transverse section.

is smooth in outline except in advanced examples of the disease, when nodular projections appear in the kidney outline. The consistency of the growth is firm except when degenerative changes have occurred. On section the tumour has an appearance resembling closely grained muscle; greyish-yellow areas may appear, and in late

cases the bulk of the tumour may present this appearance. Darker areas represent points of hæmorrhage, and cyst formation may be evident. The remains of healthy kidney tissue may be seen as a capsule-like arrangement surrounding the tumour.

A point of importance is the condition of the renal pelvis. A quill-like ureter is attached along the mesial edge, but there is no appearance of a pelvis, and dissection shows that the calyces are absent.

It is reasonable to suppose that a kidney which is so affected has no secretory functions, and that after the tumour has developed no fluid passes along the ureter.

Various observers have recorded the comparatively small size of the renal arteries in these cases.

Microscopical examination shows that the bulk of the tumour is composed of tissue in which the cells are arranged upon a tubulo-

acinar plan—at first sight it resembles adenomatous tissue, but in several points (the absence of a basement membrane, for example) it differs from true adenomatous tissue. A varying amount of the bulk of the tumour is composed of tissue resembling a sarcoma, in which round cells and spindle cells predominate. A study of these tumours in various stages of growth indicates that there is a metamorphosis of the tubulo acinar tissue into a sarcomatous type, and the longer the tumour is in existence the more extensive is this conversion.

The entire tumour is permeated with a loose fibrillar like network of connective tissue fibrils, while septa of a denser character radiate from the position of the pelvis and tend to divide the whole into arc like divisions. Groups of non striped muscular fibres exist throughout the tumour substance. These collections are chiefly found in the position which the kidney pelvis ought to occupy, and their tissue is probably derived from the non striped muscle which normally exists in the wall of the pelvis.

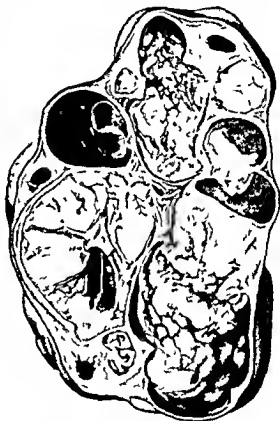


FIG 445.—Tumour of kidney (Child 2½ years old)

Apparently of a papillo cystic type but shown by microscopical examination to be an example of an embryoma (adeno-sarcoma)

The Origin of the Tumour. Various views have been put forward. It has been taught that the tumour arises from inclusion of Wolffian tissue or that aberrant cells of the myotomes and sclerotomes form the origin. The most recent view is that the tubulo acinar tissue arises from the embryonic convoluted tubules. It is supposed that because of an error in the blood supply, the formation of the Malpighian corpuscles has been interfered with, the convoluted tubercles have therefore never fulfilled their normal function, and have therefore become prostituted into a tubulo acinar arrangement. Since the nephrogenetic cells of the metanephros or true kidney are mesoblastic in their origin, it is possible for them to

develop into a tumour of a sarcomatous type, and this theory explains the conversion of the original tubulo-acinar tumour substance into one of a sarcomatous nature.

CLINICAL FEATURES

While hæmaturia, pain, and the existence of a tumour are the accepted signs of a renal growth, in the case of the embryonic tumour, hæmaturia is absent. The reason for this is that the swelling from its earliest beginnings is a development within the kidney, and con-

sequently the tubules, the calyces and the pelvis are so pressed upon and obliterated that no urine is voided from the affected side. It is conceivable that, if the extent of the central growth is small at birth, a history of former hæmaturia may be obtained; we have had this experience in one case, but, as a rule, by the time the child is born the central tumour is so large as to obliterate the calyces and pelvis.

If the child is old enough, pain is complained of. The most distinctive feature is the large size of the tumour. After a certain stage it grows with great rapidity so that it becomes dis-



FIG. 446.—Adeno-sarcoma of left Kidney (Baby 1½ years).

The outline of the tumour is depicted on the child's abdomen. The bulging of the loin and the enormous bulk of the tumour are well shown.

cernible from the first. Constipation accompanies the kidney swelling, and is the result of pressure upon and displacement of the colon; a failure in general health and in weight is evident in the later stages of the disease.

Recognizing that the pathology suggests that the tumour evolves from tubulo-acinar structure of low malignancy to sarcomatous tissue of high malignancy, there is the interesting clinical fact that coincident with the appearance of the sarcomatous tissue, the general features of the disease increase in intensity. Metastasis occurs by way of the veins or by infiltration of the surrounding tissues and

lymphatics The tendency to spread increases as the sarcomatous stage develops

DIAGNOSIS

A rapidly growing tumour in the lumbar region of a child, with symptoms of emaciation and cachexia, usually means a tumour of the kidney

This point having been established, two factors suggest that one is dealing with an embryonic mixed tumour —

- (1) The absence of hæmaturia, except occasionally in the early stages of the disease
- (2) The uniform enlargement of the whole outline of the kidney

Certain extra renal conditions may simulate the disease. A rapidly growing mass may be *malignant disease of the retro peritoneal glands*. The tumour of the kidney has a lateral position, while the glandular mass is centrally placed, with an area of resonance around it. *Renal tuberculosis* must be thought of, but the tuberculous kidney in the child rarely reaches any great size, moreover, the kidney outline is irregular, and characteristic signs are generally present in the urine. *Splenic enlargement* due to leukæmia or syphilis will have to be differentiated. *Hydronephrosis* develops slowly, and rarely reaches the large size of renal growths. Sudden variations in size often characterize a hydronephrosis.

Ovarian tumours are so infrequent in childhood that they may be practically disregarded, and the same is true of *echinococcal* cysts.

Tumours of the Liver are rare in children. In such cases jaundice is likely to be present, but one must remember that a tumour of the right side under the ribs, accompanied by jaundice, may be a renal growth which has compressed the bile ducts. In liver enlargement the anterior border is distinctive in so far as it is well marked, and extends in a lateral line across the abdomen.

Tuberculous peritonitis associated with *tuberculosis mesenterica* is sometimes difficult to differentiate.

TREATMENT

Early operation offers the only prospect of success. An appreciation of the pathology makes it evident that if the best results are to be obtained, the kidney must be removed before the sarcomatous change has become established. The favourable cases are those in which the kidney is of moderate size and smooth in outline, nodulation of the surface indicates that the sarcomatous degeneration has extended beyond the limits of the organ.

On account of the size of the tumour, removal through the loin is generally impracticable. It is necessary to employ a paramedian incision or a lateral transverse incision. After the abdomen is opened the peritoneum overlying the tumour is incised to the outer side of the

colon, and the bowel is separated inwards towards the midline. When operating on the right side, the separation of the duodenum demands special care—the second part may be adherent to the anterior surface of the tumour.

It is generally an easy matter to shell the tumour out of the bed in which it is lying. The vessels are ligatured and severed, and the ureter is divided at as low a level as possible. After removal of the tumour the retro-peritoneal space is shut off by suturing the divided posterior peritoneum.

Sarcomata and Hypernephromata. The occurrence of kidney tumours of this nature is exceedingly uncommon in children. A detailed account of them is unnecessary, as their characters are similar to those met with in the adult.

Hydronephrosis. It is convenient to adopt the classification of congenital and acquired of hydronephrosis.

Congenital Hydronephrosis.

Examples of the disease appearing in the foetus, in the newly-born, or in the infant soon after birth, are included in this category. The condition is usually bilateral, and in this event the most frequent cause of its occurrence is found to consist in valvular duplications of mucous membranes existing in the posterior urethra (Proust's valves). The disease is confined to the male sex.

Unilateral examples are exceedingly rare, and the only cases we have seen have been in connection with congenital malformations of the lower end of the ureter and abnormal implantation of this structure, but it is conceivable that any congenital obstructive influence exerted upon the ureter may induce a unilateral congenital hydronephrosis.

THE PATHOLOGY of the congenital bilateral type of the disease is peculiar to childhood and particularly characteristic, as the obstruction usually exists in the posterior urethra in the vicinity of the external sphincter. The internal sphincter and the urethra above the obstruction are dilated, the bladder is enlarged, and its walls show well-marked hypertrophy. The ureters are enlarged to many times their normal size, and they acquire a tortuous outline so that they resemble coils of small intestine. The pelvis of the kidney and the kidneys themselves show the characteristic signs of a hydronephrotic enlargement.

Sooner or later infection of the upper urinary tract occurs, and the changes become those of pyonephrosis.

The treatment is alluded to in connection with hypertrophy of the bladder.

Acquired Hydronephrosis.

This variety of disease is very uncommon; it may be unilateral or bilateral, and arises from such conditions as pressure upon the ureter by an ovarian tumour, impaction of a ureteric stone, or

obliteration of the ureters by tuberculous peritonitis or cascating tuberculous glands. There has not been a single example of acquired hydronephrosis in the records of the Edinburgh Children's Hospital during the past fifteen years, sufficient evidence of the rarity of the condition!

Polycystic kidney Enlargement of the kidney, the result of multiple cystic disease, while not amenable to operative interference, requires consideration because of its importance in regard to surgical diagnosis. The condition is one in which one or both kidneys is the site of a multiple cyst formation, the cysts developing in the renal parenchyma.

ETIOLOGY The views in regard to the origin of the disease may be summarized into three groups —

- (1) *Virchow's theory* that the disease originates because of a chronic interstitial inflammation, probably foetal in date the cysts being retentive in type, and the result of obstruction of the tubules of the kidney.
- (2) *The multilocular cyst adenoma theory*—which holds that the cysts are degenerative in origin.
- (3) *The congenital theory*, that the cysts develop because of an imperfect fusion between the excretory and secretory germ elements. Foissin has recorded a case in a newborn infant in which he found an obstruction in the collecting tubules.

PATHOLOGY The kidney tissue is the site of numerous cysts of varying size. They contain clear fluid, and their walls are lined with flattened epithelium, intra cystic papillary projections are occasionally found, and the endo tubular endotheum is proliferated. Normal renal tissue occupies the spaces between the cysts, but this substance is often the site of sclerosis and areas of small celled infiltration. Germinal centres of epithelium of foetal origin are often found throughout the kidney substance. The liver may show changes similar to those described in the kidney, and this fact has been quoted as substantiating a congenital origin of the disease.

SIGNS AND SYMPTOMS Cachexia, the result of metabolic deficiency, accompanies established cases of the disease, but, in early cases and in unilateral examples, symptoms may be absent. Haematuria occurs in about 30 per cent of the cases.

The urine remains normal in amount until towards the end, when the quantity diminishes. The specific gravity is lowered, the reaction is acid, and the percentage of urea is diminished, there being traces of albumin and a few granular casts. The tumour of the enlarged kidney is usually palpable.

R. L. Stewart believes that the pyelogram appearance of the renal pelvis is distinctive.

While no surgical treatment is of avail, the possibility of the disease must be considered where questions of diagnosis are concerned.

Stones in the Kidney Stones in the kidney are occasionally met

with during childhood. In our experience a chronic pyelitis often originates the stone, and it would seem reasonable to believe that the catarrh accompanying the inflammatory lesion forms the nucleus of the calculus. The disease is more frequent in children who reside in districts in which stone is endemic, and in this connection the proportion of calcium in the drinking water is evidently an important factor. Boys are more liable to the disease than girls.

PATHOLOGY. Phosphates of magnesium and lime are the most frequent constituents, small amounts of uric acid and calcium oxalate being present in addition. Pure uric acid stones are occasionally found.

SYMPTOMS. The symptomatology has one peculiarity which distinguishes it from that of the adult: the evidences of pyelitis and pyelonephritis begin early and persist throughout the history of the case. Apart from this distinction, the features in the child are similar to those in the adult: there are paroxysms of pain in the loin, which may be followed by hæmaturia, frequency of micturition is complained of, and the urine contains pus. The kidney may be tender to touch, X-ray examination reveals the presence of the stone, and the pyelogram appearance may be distinctive. Many examples of the disease have a tendency to remission of symptoms, and the disease may run a chronic course.

If unrecognized and untreated, various complications may ensue. Hydronephrosis or pyonephrosis may develop, or a peri-renal abscess may form.

DIAGNOSIS. A chronic pyelitis which has failed to respond to the usual remedies should arouse suspicions of a renal stone.

Tuberculosis of the kidney simulates a renal calculus, and it may be impossible to differentiate between the two conditions until an X-ray examination has been made.

TREATMENT. When a stone is demonstrated, the sooner it is removed the better; if left *in situ* it will inevitably end in complete destruction of the kidney. In view of the fact that so much infection accompanies the stone, the operation of nephrolithotomy is so planned that, if possible, the stone is removed through the pelvis. The method of incising the kidney at its convex edge and removing the stone through this route should not be practised in the child because of the risks of infection and of secondary hæmorrhage.

II. DISEASES OF THE BLADDER

ANATOMY. The position and form of the bladder are not the same in early life as in the adult. In the newborn child it rises much above the brim of the pelvis into the hypogastric region of the abdomen, and has little or no basal surface, simply tapering down to the urethral orifice, which is the lowest part, and is opposite the upper border of

of the pelvic bone are ununited at the ventral midline. That the developmental error which is responsible for the defect occurs early in foetal life is demonstrated by the imperfect low umbilicus. This structure is scarcely noticeable as it joins the upper bladder mucosa, and therefore the defect must have occurred at a period when the allantois was present as such.

Embryologists have had difficulty in offering an explanation of the process which has produced the extroversion, but the work of Keibel and Vraileton and subsequently of Reichel and Berry Hart afford a clearer understanding of it. The most recent work on development shows that the cloaca extends from the umbilicus to the base of the tail. Into the cephalic end of the cloaca there opens the allantois (bladder) in front and the hindgut (rectum) behind. A septum develops between the two, and as the septum descends caudally it divides the cloaca into a dorsal or anal portion, and a ventral or urogenital sinus. The allantois therefore opens into the urogenital sinus, and about the second month the bladder develops as a dilatation implicating the cephalic end of the sinus and possibly a portion of the caudal end of the allantois. The anterior wall of the cloaca and therefore of the urogenital sinus is formed by the *cloacal membrane* (*anal membrane*), and within the membrane there later develops the anterior abdominal wall and the anterior wall of the bladder. It would therefore seem that an error in the development of the cloacal membrane is responsible for extroversion of the bladder, and it is suggestive that, at a certain period, the membrane has no mesoblast in its constitution and is thereby correspondingly weak.

The reason why the error should appear is difficult to define with any certainty. Keith is inclined to believe that a rupture of the cloacal membrane occurs secondary to a dropsy of the cloacal cavity, and he instances parallel conditions in the neural canal and the pericardium. A mechanical view has been put forward which suggests that the umbilical cord passes round the tail end of the embryo to a placenta which lies at the back of the embryo (the cord in later life passing between the infant's legs): the pressure of the cord in this incorrect position might, it is claimed, lead to imperfect formation of the membrane or to its rupture.

CLINICAL PATHOLOGY

At the birth of the child, a rounded red swelling is found to exist in the midline of the abdomen below the umbilicus. It is roughly triangular with the apex downwards, and its size is about that of a small hen's egg. The swelling is found to be the posterior wall of the bladder, which in the absence of the anterior wall of bladder and abdomen is projected forwards by the intra-abdominal pressure. The floor of the triangle is formed by the mucous membrane, which is infolded and irregular; it is continuous with the surrounding skin,

through a zone of imperfect epithelium. At the upper junction of skin and mucous membrane there is a transverse area of scar tissue, the '*hypogastric fold*'.

The lower part of the extroversion corresponds to the trigone of the normal bladder. It is somewhat overshadowed by the more prominent upper portion, and its mucous covering is smooth.

If the prominent portion is gently elevated, two nipples are seen, upon each of which a ureter opens. The nipples are situated more closely together than normally, and the ureteric openings are frequently dilated. Jets of urine may be seen to escape from the orifices, and the



FIG. 448.—Extroversion of Bladder and Epispadias (Boy 6 months old)
The testes are retained.

surrounding mucous membrane is constantly moist. The muscular wall of the ectopic bladder is thicker than normal.

When the surrounding parts are examined, it is found that the mal development is not confined to the bladder. The umbilicus may be normal but more frequently it is displaced downwards, and its outline is lost in the muco cutaneous junction. The penis is a flat projection about 1 inch long, the corpora cavernosa and the glans are undeveloped, and along the dorsum of the penis runs a shallow median groove representing the urethra (epispadias). If the rudimentary penis is displaced downwards a small moist pocket lined with a brilliant red mucous membrane is found on the upper surface at the

base, and within this space lie the sinus pocularis and the openings of the ejaculatory ducts.

At the end of the penis a rudimentary apron-like foreskin hangs downwards. The scrotum is generally mal-developed, the testes being retained in the inguinal canal. Sometimes the scrotum is split, and each half may contain a testis. The prostate is rudimentary or completely absent. The pubic bones are ununited in the ventral midline by a space of varying degree. The existing bladder wall being abdominal, the pelvic course of the ureters is altered; they form a deep loop in the pelvis between the bladder and the rectum, and their course is therefore longer than normal.



FIG. 449.—Extroversion of the Bladder.

The child is of the female sex. There is a double inguinal hernia, and the ovaries enter the sac. The muscular defect of the abdominal wall is unusually extensive.

that about 20 per cent. of the cases are female. The appearance is very similar to that found in the male with certain changes peculiar to the sex. The clitoris is divided, the labia minora are separate, double hernia may be present, and, if the ovaries descend into the sac, as they sometimes do, there may be difficulty in deciding the sex of the individual.

CLINICAL FEATURES

The appearance of the deformity has been described. The exposure and the irritation of the bladder surface and the odour of the leaking decomposing urine produce such a distressing condition that, if the individual survives, the society of others is shunned, and he or she leads an isolated existence. When these cases are old enough to walk they

The perineal muscles are sometimes ill-developed, and an effort should always be made to ascertain whether the anal sphincter is affected, as this knowledge may influence the eventual choice of surgical treatment.

The pathology described above is such as is met with in a well-marked case of the deformity, and the majority of cases come under this heading, but varying degrees of the error are met with. Some are so slight as to show only scarring in the supra-pubic region, others have a more extensive deformity than that described, for, in addition to the bladder error, the ilco-cæcal region of the intestine is absent, and the ileum opens in a common cloaca behind the ureters.

The Condition in the Female.

The condition is not so common in the female as in the male; it is said

exhibit a characteristic gait. Owing to the tenderness of the lower abdomen they hold themselves in a forward stooping position, and a persistent lordosis is thus acquired. Because the pelvis is broad and flat, the femora are turned outwards and a waddling gait results, which is not unlike that displayed in bilateral coxa vara.

But the span of life is short. Statistics show that 50 per cent of all persons thus afflicted succumb before the tenth year, and 66 per cent are dead before the twentieth year. The reason for the comparatively short duration of life is the kidney infection which inevitably occurs—an ascending secondary nephritis is the commonest sequel, while in certain cases the thickened bladder wall narrows the lower



FIG. 450—Extensive Extroversion of Bladder in female Child.
Both ovaries are present in hernial sac.

end of the ureters so that a hydro ureter and a hydronephrosis with subsequent hyonephrosis develop.

TREATMENT

Every one is agreed that surgical measures of some description are indicated in the treatment of the deformity. There is difference of opinion as to when the operation should be done and the exact form which it should take. To leave the condition indefinitely is to inflict discomfort and distress upon parents and child, with the added certainty of an early fatal result.

When should the Operation be done?

The answer to this question depends to some extent on the consideration which follows, viz. the form which the operation should take. We may, however, consider some general aspects of the problem:

There are three age periods which have been suggested as suitable:—

- A. As soon after birth as possible.
- B. After the second year.
- C. About the period of puberty.

Each of these has points of recommendation and of disadvantage

(A) *Operation soon after birth* has two advantages: (1) the problem is faced early, and suffering and discomfort are thereby reduced to a minimum, and (2) the operation is completed before infection of the kidneys has occurred.

Against these advantages, however, we have to put a consideration which more than counterbalances them—at such an early age the operation mortality is so heavy as to make this choice almost prohibitive

Considering the opposite extreme, (C) *Operation about puberty*, the advantage adduced is that the operation can then be done with a small mortality, but we have to bear in mind that by that period it is a case of survival of the fittest, and that a large proportion of the earlier cases whose lives might have been prolonged by an earlier operation have already succumbed. Some consideration must also be given to the long years of discomfort and misery which patient and friends have had to endure.

There remains the period (B) when the child is about two years old. This is the choice which we have always favoured. The operative mortality is low, the kidney infection is unlikely to have been established, and a successful operation brightens the outlook of the period of the childhood.

What form should the Operation take?

The ideal operation would be one which ensured the formation of a receptacle for the urine and yet fulfilled two conditions—that the receptacle is under the control of the voluntary nervous system, and that there is no liability to post-operative infection of the kidneys.

A great variety of methods has been used in the attempt to secure the ideal, and it is of interest to note the more important of them.

It was a natural idea to imitate the physiological condition in birds, and to convert the rectum into a common cloaca by transplantation of the ureters. This procedure, modifications of which rank among our most modern methods, was first attempted unsuccessfully by Simon in 1851. In 1878 Thomas Smith transplanted both ureters into the

rectum extraperitoneally, and again a fatal result followed. Gluck and Zellen in 1881 carried out a series of experimental animal transplants of the ureter into the intestine, and the high mortality of experiments brought the cloacal method into disfavour.

The apparent failure of the transplantation operation led to the revival of various plastic operations. In 1852 Roux developed special plastic procedures for the formation of a bladder, and additions and improvements were later devised by Nelaton (1854), Thiersch (1876), and Wood (1880). The plastic method never became a popular one owing to the necessity of using adjacent hair growing skin, which accumulated lime deposits and added to the foulness of the uncontrolled urine, and even the most efficient plastic operation does not secure control. That the plastic method has not been entirely abandoned is evident, however, by the results published by Kanavel in 1917, in which he advises the use of transplants of fascia lata for extroversion of the bladder and for spina bifida.

In 1885 Trendelenberg made an attempt to improve the plastic methods by compressing the ununited pubic arches, and so aiding closure and formation of the bladder, and in 1892 he improved the method by separating the sacro iliac joints as a preliminary. König (1896), Koeh (1897), and lately Albarran (1909), have acted on Trendelenberg's suggestion, but a high immediate mortality and many subsequent operative failures have discredited the method.

In 1896 there was a return to the transplantation operation when Mayl carried out a successful intra peritoneal transplantation of the base of the bladder with the attached ureters into the sigmoid. For a time this became the popular operation, and a series of cases was reported showing an average mortality of about 25 per cent. In 1899¹ Lendon and Peters improved the operation results by transplanting the ureters extra peritoneally into the rectum, and Jaga in 1901 carried out the same procedure intra peritoneally.

This survey does not exhaust the various measures which have been attempted. Valve types of operation were performed by Fowler in 1898 without any lasting success. In the same year Rutkowski successfully utilized an isolated segment of the small bowel to cover in the defective bladder. Werelius in 1911 developed various methods of partially excluding the segment of bowel to which the ureters were united, and since 1901 a group of interesting and ingenious operations has been devised with the idea of fashioning a receptacle from the bladder tissue which exists and giving it a sphincter action by drawing one end of it through a tunnel fashioned between the sphincter ani and the rectal mucosa.

It is impossible in a work of this description to give a detailed account of the various measures suggested, and we have merely attempted to show the evolutionary stages towards a satisfactory

¹ Bergenheim had advised and actually performed this operation as early as 1894.

method. Anyone who is specially interested should consult the original literature on the subject.

Among such a variety of operations it is difficult for the beginner to choose a method, and he has largely to be guided by the advice of others. From the experience which we have had in a considerable number of cases, we have no hesitation in advising an intra-peritoneal transplantation of the ureters into the large intestine followed subsequently by an extra-peritoneal excision of the bladder wall. This method has many advantages—the procedure is simple, the mortality is small, the operation may be carried out at an early age, and the functional result is good.

DESCRIPTION OF THE OPERATION

Preliminaries. The operation is not performed until the child is over two years old. The general health should be good, and, as primary union of the abdominal wound is essential, a preliminary period is spent in getting the surrounding skin into as healthy a condition as possible. There is an advantage in a short pre-operative administration of urotropine.

Two operations are performed, one on each ureter, at intervals of a fortnight.

The Operation. The child is placed in the Trendelenberg position, and, in order to prevent any escape of urine from the bladder surface, a sheet of sterilized dental rubber is carefully clipped around the mucocutaneous edge, and the clipped edge is covered with a thick layer of bismuth-iodoform paste.

We employ a gridiron incision, as the longitudinal incision, when used in a small child, is associated with greater shock, and with increased risk of sepsis.

The right ureter is transplanted first, because the bowel may be so fixed by a primary left operation as to endanger success when the right side is undertaken. The abdomen is opened by a gridiron incision on the right side, the small intestine is packed away, and the ureter is recognized as it crosses the brim of the pelvis. The overlying peritoneum is divided, and about $1\frac{1}{2}$ inch of the ureter is separated. The lower end is divided about 1 inch from the bladder wall, the distal end is ligatured, and the proximal end is controlled by a light spring clamp which prevents escape of urine. The wound in the posterior peritoneum is closed by a running suture of light catgut, which unites the peritoneum up to the point of emergence of the ureter and buries the distal ligatured stump.

The lower part of the pelvic colon is now pulled up and a loop about 3 inches in length is clamped in the long axis of the bowel. In the child the gut in this situation shows a uniform distribution of the longitudinal muscular coats.

At a point opposite the isolated ureter an incision $1\frac{1}{2}$ inch long is made through the outer coats of the bowel in the line of the longitu-

dinal muscle Following the method advised by Coffey, the incision is carried to the mucous membrane, but not through it, and on each side of the incision the mucous membrane is slightly separated from the overlying muscular tissue

Attention is now paid to the end of the ureter Following the technique which Stiles described, the lower end of the ureter is split upwards for a $\frac{1}{4}$ inch to lessen the liability to stenosis, and with a round curved needle it is transfixed with a piece of fine catgut (No 0), a single suture being sufficient Returning to the colon, the exposed mucous membrane is now perforated with the cautery at the lowest part of the incision in the muscular coats The curved needle is inserted through the opening into the bowel to emerge $\frac{1}{2}$ inch lower down Tension on the catgut draws the ureter into position and, in order to fix it, the needle is passed through a fold of intestine at the point of emergence Interrupted or a continuous catgut suture now approximates the divided peritoneum and muscle of the intestine over the ureter, and Charles Mayo advises that every other suture should catch a bit of the outer wall of the ureter in order to fix its position

At the upper angle of the incision Mayo recommends that an adjacent fat tag should be caught by the catgut to relieve ureteral pressure

The interrupted sutures are covered with a continuous catgut suture, which extends over the extremities of the original incision Two or three additional interrupted sutures adjust the bowel to the parietal peritoneum in such a way as to prevent any kinking of the ureter The advantages of this method are obvious—the ureter before entering the bowel lumen is covered internally for a distance of about $1\frac{1}{2}$ inch by mucous membrane only, and any increase of internal pressure will close the ureter against ascending gases and liquids, while it does not prevent the normal intermittent emptying by ureteral peristalsis

After a period of ten to fourteen days the operation is repeated on the left side, and the left ureter is transplanted into the pelvic colon at a slightly lower level than that of the right side

POST OPERATIVE TREATMENT The operation is associated with a wonderfully slight degree of shock Apart from such gross complications as peritonitis, the main anxiety is during the days which succeed the first operation At this period the bowel appears to be unaccustomed to the presence of urine in its interior and there is a considerable absorption of urine with symptoms of a mild uræmia It is therefore important that frequent warm saline irrigation of the lower bowel should follow certainly the first, and preferably both, operations

In a successful case the convalescence is an uneventful one At first urine is frequently voided from the rectum apart from the motion, in the course of time, however, a wonderful degree of control is possible,

method. Anyone who is specially interested should consult the original literature on the subject.

Among such a variety of operations it is difficult for the beginner to choose a method, and he has largely to be guided by the advice of others. From the experience which we have had in a considerable number of cases, we have no hesitation in advising an intra-peritoneal transplantation of the ureters into the large intestine followed subsequently by an extra-peritoneal excision of the bladder wall. This method has many advantages—the procedure is simple, the mortality is small, the operation may be carried out at an early age, and the functional result is good.

DESCRIPTION OF THE OPERATION

Preliminaries. The operation is not performed until the child is over two years old. The general health should be good, and, as primary union of the abdominal wound is essential, a preliminary period is spent in getting the surrounding skin into as healthy a condition as possible. There is an advantage in a short pre-operative administration of urotropine.

Two operations are performed, one on each ureter, at intervals of a fortnight.

The Operation. The child is placed in the Trendelenberg position, and, in order to prevent any escape of urine from the bladder surface, a sheet of sterilized dental rubber is carefully clipped around the mucocutaneous edge, and the clipped edge is covered with a thick layer of bismuth-iodoform paste.

We employ a gridiron incision, as the longitudinal incision, when used in a small child, is associated with greater shock, and with increased risk of sepsis.

The right ureter is transplanted first, because the bowel may be so fixed by a primary left operation as to endanger success when the right side is undertaken. The abdomen is opened by a gridiron incision on the right side, the small intestine is packed away, and the ureter is recognized as it crosses the brim of the pelvis. The overlying peritoneum is divided, and about $1\frac{1}{2}$ inch of the ureter is separated. The lower end is divided about 1 inch from the bladder wall, the distal end is ligatured, and the proximal end is controlled by a light spring clamp which prevents escape of urine. The wound in the posterior peritoneum is closed by a running suture of light catgut, which unites the peritoneum up to the point of emergence of the ureter and buries the distal ligatured stump.

The lower part of the pelvic colon is now pulled up and a loop about 3 inches in length is clamped in the long axis of the bowel. In the child the gut in this situation shows a uniform distribution of the longitudinal muscular coats.

At a point opposite the isolated ureter an incision $1\frac{1}{4}$ inch long is made through the outer coats of the bowel in the line of the longitu-

John Thomson believed that it was due to 'the existence in *utero* of a state of incoordination between the sphincter and detrusor muscular apparatus of the bladder,' so that a congenital hypertrophy resulted. Sollingen suggested that the condition was due to changes in the sympathetic ganglia. More recently Proust, and later, Young, Froutz, and Baldwin, described congenital valvular obstruction in the posterior urethra, which they claim to be responsible for the bladder changes.

CLINICAL FEATURES The features primarily associated with the condition are those of dysuria, a small irregular stream on micturition, incontinence, and occasional attacks of retention. As hydro-nephrotic changes become evident in the kidneys, signs of chronic nephritis set in, and the end comes when a pyonephrosis develops. It may be possible to palpate the enlarged kidneys and dilated ureters through the abdominal wall.

DIAGNOSIS The diagnosis is founded on the history of the urinary symptoms, on the existence of the hypertrophied bladder, the enlarged ureters and kidneys, and on the characteristic X-ray appearance when the bladder is filled with a 20 per cent solution of sodium bromide solution.

TREATMENT Success has followed operative interference in which the valvular obstruction of the urethra is removed by a specially designed punch (Youngs).

NORMAL MICTURITION AND THE CHARACTERS OF THE URINE

The new born infant usually passes water a few hours after birth, as urine is secreted in the later months of intra-uterine life. At first the water is passed very frequently, though during sleep the intervals are longer than when the child is awake. Control of the act of micturition should become apparent about the end of the second month, though a great deal depends upon the training which the child receives.

The Collection of the Urine It is often a matter of difficulty to obtain a sufficiency of urine for examination. In boys a small test tube may be fastened around the penis with a band of sticking plaster, in little girls the use of a warmed bedpan may succeed. An intelligent nurse may secure a specimen by waking the child from sleep, placing it on a small basin, and at the same time exerting pressure over the bladder.

Characters of the Urine The reaction of the child's urine in health is faintly acid, and any exaggerated reaction, either acid or alkaline, is an indication of disorder. The specific gravity is at first a low one (1.002 to 1.004), after six months it begins gradually to increase so that about the seventh month the average specific gravity is 1.020 to 1.030. The amount passed *per diem* shows a progressive increase as the child grows—a baby a week old passes

and the urine is retained for periods of from five to six hours. During the hours of sleep there is frequently a slight escape of urine.

Congenital Absence of the Bladder

Congenital absence of the bladder may accompany extensive congenital malformation of the pelvic organs. Errors of this extent are generally incompatible with life.

Benningen has described a case in which the bladder was absent in an otherwise healthy individual; the ureters opened into a sac-like projection of the urethra.

Congenital Vesical Septa

A number of cases have been recorded in which the bladder lumen was divided into two compartments by an incomplete septum. The dividing membrane may be longitudinal or transverse, and abnormalities in the ureters or other congenital malformations are sometimes present. These errors are exceedingly rare, and in any event there is no demand for surgical treatment during the period of childhood.

Urachal Fistula

If the lumen of the allantois remains patent a fistulous tract exists between the bladder and the umbilicus. The existence of a congenital obstruction is said to be the reason why the closure of the allantois is delayed, but in two cases which have come under our own observation no obstruction whatsoever could be detected. It is evident that some other factor must be at work.

The umbilical end of the fistula is apparent as a small point of granulation tissue, and there is a constant escape of urine from the orifice. During the act of micturition the urine escapes in a jet. The connection of the fistula with the bladder is demonstrated by introducing a solution of methylin blue through the urethra and observing its escape from the fistula.

TREATMENT. Complete excision of the tract is the only efficient method of treatment. The removal can be carried out extra-peritoneally.

Urachal Cysts. The persistence of localized unobliterated portions of the urachus may lead to the development of urachal cysts. These are treated by excision or by drainage.

Congenital Dilatation and Hypertrophy of the Bladder

This condition has been alluded to in connection with double congenital hydronephrosis. It occurs in boys only, and consists in a pre-natal dilatation of the bladder with hypertrophy of its wall and with secondary associated changes in the ureter and kidneys in the shape of hydro-ureter and hydro-nephrosis.

There is still some doubt regarding the origin of the condition.

supervenes, and a hæmaturia occurs. The condition is always temporary, and leaves no permanent defect.

In other cases, *nephritis* may be the underlying cause, and in a surgical ward this possibility may be overlooked.

Renal tuberculosis is the most frequent cause of renal hæmaturia. *Oxaluria*, particularly liable to occur during the 'rhubarb season' may be the origin of a renal bleeding, and so may uric acid crystals. Children who suffer from scurvy or purpura often show blood in the urine. *Stones in the kidney* and *renal tumours* are rare causes.

The bladder conditions associated with hæmaturia are stone, tumour, tuberculosis of the bladder wall, acute cystitis, and streptothrix ulceration of the trigone as met with in female children.

Hæmoglobinuria is a rare event. The underlying disease in some cases would appear to be congenital syphilis, but the connection between the two is not understood.

Coloured Urine. A child was recently admitted to the surgical wards of the Children's Hospital because it was said to be passing blue urine. There was certainly no doubt as to the correctness of the description, but investigation showed that a well known proprietary pill had been given by the parents, and, as the preparation contained methylene blue the solution of the mystery was apparent. Eating sweets coloured with aniline dyes may result in the passage of pink urine. In carbolic acid poisoning and during the administration of salol the urine may acquire a dark sage green colour. Black urine or *alkaptonuria* is a rare congenital abnormality, the origin of which is unknown.

DISORDERS OF THE FUNCTION OF MICTURITION

Urinary Incontinence and Nocturnal Enuresis in Children

The general practitioner is not long in practice before he comes in contact with examples of urinary incontinence in children and, when these cases present themselves, the doctor recognizes that he has to deal with one of the most difficult of all diseases from a curative point of view. In treating such cases it is important to consider them from a patho physiological standpoint, the basis from which all clinical problems should be approached.

What are the Clinical Conditions included in the Disorder? There is a wide range of clinical possibilities. It may be that the child passes water during wakeful hours with greater frequency than normal the frequency being invariably increased by any mental excitement (*Pollakuria*). There is no real incontinence, and during sleep no error is apparent. This is the slightest form which the disorder assumes.

On the other hand, there is a common form of the disorder in which the sequence would almost appear to be reversed—during the day the

2 to 3 ounces in twenty-four hours, by the second year the average amount reaches 15 to 20 ounces, during the twelfth year it averages 35 to 45 ounces. The urea content is an estimation which frequently requires consideration in surgical conditions. Holt states that children three to five years old average 13 to 14 grammes per day, from five to thirteen years, 16 to 21 grammes.

Exaggerated Physiological Contents of the Urine: their Clinical Significance and Influence. *Excess of Uric Acid and Urates.* During the first week of life the urine of the infant shows a relatively high proportion of uric acid, and at this period the straight tubules of the kidneys may show '*uric acid infarcts.*' After this age the increasing quantity and greater dilution of the urine washes out the deposit, and thereafter the amount of uric acid diminishes. While the excess of uric acid is being excreted, various symptoms and signs may develop—acute pain, restlessness, screaming, albuminuria, and even hæmaturia. This condition is treated by giving alkalis and water freely; citrate and acetate of potash, 10 grammes in a day, well diluted with water, may be given.

An excessive amount of uric acid, urates, or oxalates, is frequently found in the urine of children beyond the period of infancy. Temporary evidence of this disorder is found during any pyrexial illness and particularly during acute suppurative infections. A similar condition occurs in the course of the various anæmias.

Highly strung, neurotic children are often the subjects of excessive production of both uric acid and urates; a dietetic error is usually the exciting factor, particularly excess of farinaceous foods and sugars.

The condition is corrected by altering the diet, by the giving of water freely between meals, especially Vichy or Contrexeville water, and by the administration of a mixture containing citrate of potash, sodium salicylate, and a few minims of tincture of rhubarb.

Phosphaturia. Large amounts of triple phosphate crystals are sometimes found in children's urine. These may be responsible for frequency of micturition and dysuria. Phosphaturia is sometimes due to an increase of calcium and the deposit of calcium phosphates in the urine without actual increase in the total phosphatic excretion. Inflammatory abdominal conditions are supposed to be associated with this type of the disorder, as in those cases there is a diminution in the calcium of the fæces and an increase in the urine calcium.

Frequency and pain may accompany phosphaturia. The symptoms are relieved by acid sodium phosphate and a meat diet.

Pathological Conditions of the Urine. *Hæmaturia.* The presence of blood in a child's urine is a feature which calls for immediate investigation in order that the cause and source may be discovered. There are, of course, a great variety of possible causes.

A *postural hæmaturia* may cause alarm in a surgical case; a child has been operated on for some ailment which necessitates subsequent fixation in a supine position, for some obscure reason a renal congestion

The autonomic group has two subdivisions—the sympathetic and the para sympathetic. Each of these has various functions to fulfil, and in certain instances the effects are directly antagonistic—for example, the sympathetic is usually an activator of involuntary muscle, while the para sympathetic exerts an inhibitory effect. This short explanation is necessary in order to understand what follows.

The bladder and the rectum originally formed a single cavity, but as the excretory function of the urinary apparatus became of greater importance to the individual, the two structures separated, and each became a distinct cavity with an external opening of its own. The bladder, while retaining certain characteristics of its original association with the gut (musculature), acquired additional specialized features. It is not surprising, therefore, to find that the bladder has two distinctly antagonistic systems of innervation, and it is this factor which makes the treatment of enuresis so difficult. Let us see more exactly how the nerve supply is distributed.

Both para sympathetic and sympathetic fibres are distributed to the bladder wall and its related parts, and the different groups of fibres have what appear to be directly antagonistic actions. Stimulation of the para-sympathetics produces contraction of the bladder wall, but inhibition of the trigone, the sphincter and the urethra. The sympathetic fibres antagonize the para-sympathetics, when stimulated, they constrict the sphincter, the urethra muscle and the trigone, and at the same time they relax the bladder wall.

With this knowledge it is possible to understand the reflex of micturition. The pressure of urine in the bladder beyond a certain point gives rise to rhythmic contractions of the bladder wall, and so to afferent impulses which are transmitted to the spinal cord, and from there are conveyed by the parasympathetic fibres in the pelvic nerves to the bladder. This stimulation results in relaxation of the sphincter and a commencing contraction of the bladder wall. The result of the manoeuvre is that a small amount of urine is forced into the prostatic urethra, where it comes into contact with the sensitive mucous membrane of that region and especially of the verumontanum and sinus pularis. The stimulation of these results in a stronger afferent impulse passing to the cord and a correspondingly stronger para sympathetic return. The effect is a complete contraction of the muscular fibres in the wall of the bladder and emptying of that organ. The contraction of the wall in its final stages gives rise to a new afferent impulse, which is transmitted to the bladder as a sympathetic distribution, and its effects are directly antagonistic to the former. The bladder wall now relaxes, and is ready for a further reception of urine, but the trigone contracts and so completely empties the bladder, and its contraction is immediately followed by closure of the internal sphincter. The reflex is thus completed. It must be remembered that, while the reflex is essentially involuntary and therefore persists after transection of the spinal cord at a higher level (Goltz), it is yet

child appears to be normal, but at night, during sleep, the reflex of micturition is set agoing, and the bladder is emptied (*nocturnal enuresis*).

There is a third class of the disorder, in which there appears to be a true urinary incontinence. During the day urine dribbles away at repeated short intervals of time, and during the night a similar process goes on. The child is constantly wet, and a most difficult state of affairs results.

While the clinician recognizes these three main groups of the disorder, there naturally are intermediate types,

The serious Nature of the Complaint. It is a mistake to make light of the disorder. We do not mean that the seriousness of it is to be impressed too deeply upon the child. With the nervous temperament which so often accompanies the complaint, such an impression is apt to become exaggerated, but the doctor should realize how important it is to grapple with the problem early and to use every possible means for its cure.

The patient is necessarily the main sufferer. Apart from the physical discomfort, his periods of rest may be interfered with. As he grows older and begins to appreciate more fully the nature of his complaint, he begins to lose his self-respect, he becomes shy and reticent in his relations with other children, and he loses much of the pleasure of childhood.

In many children, the condition becomes the first indication of a train of nervous disorders, frequently sexual in character, which may cripple, or mar, a promising career. There are pediatricists who say that other genito-urinary diseases may owe their origin to this disability, that cystitis and pyelitis with their unpleasant sequelæ may develop because the functional derangement associated with the incontinence renders the bladder more liable to organismal infection.

But the burden is not entirely borne by the child: the disorder may impose considerable hardships on the parents. There are difficulties with maids and nurses, household plans may have to be altered because the child cannot be taken to an hotel or to live with friends. Though it may seem a matter of small consequence to the outsider, we have known parents complain of the additional expense of the heavy laundry bill which the complaint entailed.

The Disorder considered from the Patho-physiological Basis. Apart from those cases which show a gross structural or mechanical error, examples of urinary incontinence are commonly associated with some morbid feature in the natural reflexes; it is essential therefore that the investigator should have an accurate idea of the normal process of micturition.

The group of nerve tissues which control the smooth or non-striated muscle and the secreting glands is called the 'autonomic' nervous system. The adjectives '*vegetative*' and '*involuntary*' are sometimes used in the same connection.

in the adult, and under certain conditions the synapse which is concerned in the reflex of micturition possesses such a low threshold that, in the absence of voluntary control, comparatively minor stimuli result in the reflex being completed. Common causes which give rise to an irritable condition of the synapse are rise of blood pressure, congestion of the spinal cord either from position or from a reflex source, and the repeated infliction of minor degrees of stimulation.

In many cases the nocturnal enuresis of childhood is probably the result of a synaptic error. Sleep abolishes volition, and the low threshold of the synapse for any of the reasons above mentioned permits a reflex which otherwise would not have occurred. This variety we shall speak of as *Type III*.

D The error may lie somewhere in the effector arc. Physiologically this includes motor nerve cells, nerve fibres, and the musculature in which these fibres end, in the clinical condition under consideration it means the musculature of the internal sphincter. This is the most important muscle in the micturition reflex, because it prevents the haphazard entrance of urine into the sensitive prostatic urethra, for when urine comes into contact with the specially sensitive portions in this structure it is a matter of difficulty to arrest the reflex. Any condition therefore which results in weakening of the internal sphincter is a potent cause of urinary incontinence. In children atonicity and congenital malformation are the two common errors, and incontinence from this source may be grouped as *Type IV*.

SUMMARY OF TYPES

- Type I* The result of imperfect voluntary control
- Type II* The result of excessive stimulation of the afferent nerve fibres
- Type III* The result of an irritability of the spinal synapse, the reflex resulting from a stimulus which naturally would have no effect
- Type IV* The result of an error in the musculature of the internal sphincter

EXAMINATION OF THE CASE

The aim in examination is to be able to place the case in its respective type, only when this has been done is logical treatment possible.

(a) *The Higher Control* The examination should begin with a consideration of the intelligence and mental condition of the child. If the error is an example of *Type I*, there may be definite evidence of a low standard of intelligence, or even of mental disease. It must be remembered that under this heading there has to be included the imperfect higher control which results from bad habits or from erroneous education regarding the reflex, and that during sleep voluntary control is naturally abolished.

An estimation of the effect of higher control is always difficult

under the influence of the will, and can be instituted or delayed as the individual desires.

Possible Causes of the Enuresis from the Physiological Basis. When an observer meets with a case of urinary incontinence, he is acting correctly when he considers the problem from a physiological point of view. He tabulates the four or five various sites in which the error which is responsible for upsetting the reflex may occur. By examination and careful questioning, he attempts to localize the site, and the appropriate treatment is thereby assured. Such a plan as this prevents the use of an empirical treatment which may be successful, but which in so many cases is doomed to failure. Let us attempt to classify the various forms of incontinence on this basis.

A. It is possible that no error can be detected in the actual reflex, but that the reflex is largely uncontrolled owing to a diminished or undeveloped influence from the higher nerve centres. Until the end of the second year this higher control is but imperfectly developed, and therefore what may be termed incontinence of urine (enuresis) is, up to this period, physiological. If during the third year the control is imperfectly exerted, the enuresis becomes pathological, and we may speak of it as *Type I*.

B. The error may be in the afferent stimulus which opens the reflex. Under normal conditions the original stimulus is a very gentle one caused by the accumulation of urine in a bladder which is the site of increasing rhythmic contraction. It starts the reflex, however, and, aided by volition, the relaxation of the internal sphincter permits the passage of urine into the prostatic sphincter, where the irritation of the sinus pularis and the verumontanum produces a second and stronger reflex which results in complete contraction of the bladder.

Under certain conditions the original stimulus may be exaggerated to such an extent that the influence of volition is largely counteracted and the reflex is completed almost involuntarily. Examples of enuresis of this nature are found in cases of vesical calculus, cystitis, oxaluria, and many other irritative conditions. In subsequent descriptions we will call the variety *Type II*.

C. The act of micturition being a reflex, the connecting synapse is found in the lumbar region of the spinal cord. That is to say, the afferent nerve fibres communicate by arborization with the dendrites of motor neurones, the junction being called a synapse. This synapse has a considerable influence upon the reflex; under certain circumstances it exerts a retarding influence, and more powerful stimuli than usual are required to excite the reflex: we say that *the threshold of the reflex rises*. Under other conditions the synapse appears to transmit the stimulus with greater facility than is usual, and an afferent impulse, generally insufficient, may result in the reflex being completed.

In childhood the synapse is probably more sensitive than

considerable proportion of cases in which no local feature can be demonstrated. The majority of these are examples of *Type III* (synaptic), and recognition of them is often possible by judicious questioning. They form the bulk of the cases of nocturnal enuresis. The error occurs when the child lies for any length of time in the dorsal position, it is apt to happen during deep sleep, it may appear after a period of violent emotion—all these being factors which indicate or produce an excitable condition of the spinal synapse.

TREATMENT

As has been said, a logical treatment must be based upon the recognition of the type of the disease. Much depends therefore upon the preliminary examination.

The investigation begins by ascertaining whether the case belongs to *Type II* or *IV*, and this is done by local investigation of the urine, bladder, and surrounding parts. The question of higher control is then considered, and only when these possibilities have been exhausted should *Type III*, the synaptic type, be accepted as the variety of the disease.

ACTUAL TREATMENT

Early Education. Reprimand and punishment are useless. Whatever type the disease may represent it is obvious how useless such methods are, and, in the case of the common synaptic type, immense harm is done, because the fear of punishment increases the excitability of the spinal areas.

Careful education is a very different matter, and, in those cases where no local lesion exists, careful tuition in the early months of life is of great value. All children are physiologically incontinent until the age of two years, but during this period—from the earliest months, in fact—the child should be placed upon a chamber at regular intervals of time. It is especially important that it should never be allowed to lie in a wet napkin. If these rules were more carefully followed, fewer children would suffer from this troublesome complaint.

When a fully established case calls for treatment a definite routine should be followed.

Treat a Local Lesion. A local lesion should be searched for and, if found, should be treated, and no local lesion is too slight to be neglected. The variety of treatment for the local condition will vary with the state of affairs which exists. Where *Types II* and *IV* are concerned, local treatment is essential to ultimate success.

Improve the Higher Control. If there is reason to believe that the higher control is at fault whether as the sole cause, as in *Type I*, or in combination, as in the other types, every effort should be made to educate the child in proper habits, micturition at regular intervals should be insisted on. If there is evident mental deficiency the

except in the more definite examples of defective intelligence, and, if there is any ground for doubt, a case should not be put under this heading until other possibilities have been excluded.

(b) *The Bladder, the Urine, and the Genitals.* In many cases the explanation of enuresis is found on examination of the urine, and a careful routine examination of this should always be made. There may be no very gross error apparent, but oxaluria, phosphaturia and bacilluria are frequent sources of trouble. A urine showing increased acidity may be sufficient to upset the reflex.

The interior of the bladder should call for examination: anything of the nature of a stone or a foreign body is evidenced by X-ray examination, but in intractable cases a cystoscopic examination should be made. It is remarkable how many children (especially female children) show a basal cystitis, and this may be sufficient to induce an increased afferent impulse, and so justify the classification of the case into *Type II*.

A thorough examination of the genitalia is important, because such irritation as is produced by a balanitis, for example, may be responsible for inducing an excessive afferent impulse, but, more important than this, the multiple minor impulses of a genital irritation may be the source of the synaptic irritability which is responsible for *Type III* of the disorder.

The state of the internal sphincter should be estimated. In the female this is possible by inspection, and a visual examination should be made in every case of urinary incontinence in the female child. Epispadias in the female is often a slight deformity, and many cases of apparently intractable incontinence owe their origin to this error.

In the male child, examination of the sphincters is more difficult. There is one way, however, in which an estimation may be made, and, while one does not recommend it as a routine, it should be carried out if other sources of examination are negative. Under light anæsthesia a rubber catheter is passed, and the bladder is filled with a slightly greater quantity of fluid than the normally full bladder contains. The catheter is then withdrawn, and it is observed whether any fluid escapes. With the hand a moderate amount of pressure is exerted upon the bladder, and, if the sphincter tone is normal, no escape occurs, but, if any distinct want of tone exists, the bladder will now empty.

The close association of the nerve mechanism of the bladder with that of the rectum and anal canal necessitates a careful examination of the latter for such conditions as fissure, polypi, or stricture.

(c) *Examination of the Synaptic Type—Type III.* It will always be difficult to demonstrate causal evidence in cases in which the error lies in the spinal synapse. A routine examination of the central nervous system should be made, and it may be that definite signs are elicited of nervous excitability in the shape of exaggerated reflexes. Care must be taken to exclude the presence of any organic nervous disease. But when the most thorough examination is completed, there remains a

RETENTION OF URINE

In male children mechanical retention may arise from impaction of a calculus near the meatus. A tight phimosis may have a similar effect, particularly when there is a complicating balanitis.

A reflex spasmodic retention may be associated with a painful anal fissure. Retention is often a feature in cases of pelvic peritonitis, when the dysuria which accompanies the infection ends in a true retention.

INFLAMMATORY DISEASES OF THE BLADDER

Cystitis (Non-Tuberculous)

Cystitis is a condition which one finds occasionally in children. Mild degrees of the infection are comparatively common, but the severe types which one meets in the adult are rare.

In elucidating the etiology two points have to be kept in view—(1) factors which devitalize the bladder wall and so render it more liable to infection, and (2) the routes by which infection has reached the bladder.

(1) **DEVITALIZING FACTORS** We probably underestimate the frequency with which living organisms are passed by the kidneys and secreted in the urine, and this particularly applies to young children. This fact is brought out when a cystitis develops from no very definite source of infection, but subsequent to some devitalizing influence. Cold, the obstructive effect of a tight phimosis, injury to the bladder wall by a stone, or a blow upon the bladder wall from without, are the common predisposing factors. In central nerve conditions, such as arise in association with spina bifida and the paralysis of Pott's disease, cystitis is liable to appear.

(2) **ROUTES OF INFECTION** The infection may enter by way of the urethra. This route is common in girls, when a vulvo vaginitis may result in cystitis, in boys this is an uncommon route. In the majority of cases the infection comes from above, it has either been secreted in the urine or it has been localized in the pelvis of the kidney and been washed down by the urine into the bladder. In view of the large proportion of cystitis cases which are due to infection with bacillus coli we must assume that in many cases the infection has extended from the bowel wall into the kidney pelvis and thence to the bladder.

BACTERIOLOGY A great variety of bacteria is found in the urine, and a mixed infection is frequent. The bacillus coli communis occurs more frequently than any other organism, and it may be found in pure cultures. Other bacteria are usually met with in mixed infections. They are the staphylococcus, the streptococcus, bacillus

administration of small doses of thyroid extract ($\frac{1}{4}$ grain once daily, increased gradually to 2 grains) is sometimes beneficial.

Special Treatment of the Synaptic Type. The synaptic type (*Type III*) is the variety which proves most resistant to treatment. The clinician should attempt to discover if there is anything which increases the irritability of the spinal centre, and any such error should be corrected. For example, the dorsal position during sleep increases the congestion of the spinal cord, and a wonderful effect is often produced by ensuring that the child does not sleep in this attitude. Errors in clothing which permit chilling of the lower spine are a frequent source of an irritative congestion, and often this possibility is overlooked. There are many simple points which common-sense will indicate.

Type III is the variety which yields most readily to drugs, and the successful administrations are those which diminish the irritability and the congestion of the lumbar spine. Belladonna or atropine is one which is usually tried first. It acts by lessening the irritability of non-striated muscles, and also by diminishing the irritability of the spinal centres. Liquid extract of ergot is sometimes useful; its benefit arises from its direct effect in diminishing the vascularity of the spinal centres. *Rhus aromatica* is employed with a similar object.

Counter-irritation over the lumbar spine in the shape of a cantharides blister may be beneficial in this variety of the disease, because it withdraws blood from the congested area.

OTHER METHODS OF TREATMENT

Where other means have failed, there are two operative measures which have met with success in many hands—the epidural injection of a weak solution of cocaine or of normal horse serum (Cathelin) or the retro-rectal injection of 6 to 8 drachms of serum (Jaboulay). The latter method has given better results than the former. The needle is inserted vertically at the point of the coccyx, and the index finger is inserted into the rectum to prevent penetration of the rectal wall.

Ralph Thomson has reported success following the method of injecting fluid under pressure into the bladder. A soft rubber catheter is passed, and fluid is funnelled in, at first under a pressure of 75 cm., and if necessary later under a pressure of 150 cm. The quantity injected varies necessarily with the age and size of the patient, but efforts should be made to introduce 6 ounces in children under four years, 8 ounces under eight years, 12 ounces under sixteen years. The treatment is repeated once every third day, and its aims are to increase the holding capacity of the bladder while at the same time the micturition controlling muscles are induced to work more efficiently.

It is unnecessary to keep the child in bed, but the amount of exercise should be restricted. The diet is arranged as in the acute stage. It is a good plan to change the reaction of the urine—if it is acid, alkalis are given in the form of citrate of potash and sodium bicarbonate, if, on the other hand, it is already alkaline, diluted mineral acids (boric acid and benzoate of soda and ammonia) should be given. Acid sodium phosphate is particularly useful. Urinary antiseptics (urotropin) should be given when the urine is acid.

Bladder lavage may prove successful, and in particularly intractable cases a vaccine should be used.

Streptothrix Infections of the Bladder

We have met with several examples of this interesting and rare condition. They have all occurred in girls, and the infection has been a direct one through the urethra.

The signs are those of a chronic and intractable cystitis, but the existence of hæmaturia distinguishes the disease from an ordinary cystitis.

On cystoscopic examination the trigone of the bladder is found to be the site of one or more scirrhous ulcers which are the source of the hæmaturia. It was the late Dr James Ritchie, Professor of Bacteriology in the University of Edinburgh, who demonstrated to us the streptothrix infection which is responsible for the ulceration.

The cases are treated upon the lines followed in chronic cystitis. In two instances we found it necessary to drain the bladder before a cure was obtained.

Tuberculous Cystitis

It is unlikely that primary tuberculous cystitis ever occurs, the lesion is secondary to one of two conditions—it is either the result of extension from tuberculosis of the epididymis, or it has been carried into the bladder from a tuberculous kidney.

PATHOLOGY. The distribution of the tuberculous process may be an indication of its origin, if the disease has spread from the kidney it surrounds the opening of the ureter and thence extends to the bladder base, a genital infection on the other hand begins in the neighbourhood of the internal meatus.

The tuberculous process begins as an infiltration of tubercles in the submucous tissue, eventually the overlying epithelium gives way, and a tuberculous ulcer develops. Secondary infection ultimately occurs and thereafter the tuberculous process extends with increased intensity.

SYMPTOMS. The symptoms are those of a chronic cystitis. When ulceration develops, hæmaturia appears and this feature is important as distinguishing the condition from ordinary cystitis.

TREATMENT. When tuberculous cystitis is secondary to renal tuberculosis, the kidney, if only one is affected, should be removed.

proteus, the pneumococcus, and the bacillus pyocyaneus. Anaerobic bacteria are frequently found.

PATHOLOGY. If the bacillus coli is the cause of the infection the urine remains acid. In cystitis associated with a mixed infection the urine is either alkaline or faintly acid.

The infection begins as a catarrhal inflammation affecting the trigone. There is an engorgement of the capillary vessels, the mucous membrane is swollen and œdematous, a certain proportion of the epithelium is desquamated, while the surface is covered with shreds of muco-pus and detached epithelium. Hæmorrhage may occur into the sub-epithelial tissue. The more intense degrees of cystitis, such as the hæmorrhagic, membranous and gangrenous varieties are very rarely encountered in children.

SYMPTOMS. The symptoms of cystitis are: frequent micturition, pain, and changes in the urine.

The increased frequency is the earliest and the most characteristic symptom. According to the intensity of the infection it varies from a mild frequency to a condition of virtual incontinence. Polyuria generally accompanies the frequency, and it is probably due to a reflex stimulation of the kidney.

Various types of pain are complained of. There is a scalding sensation on passing water; any attempt at holding the water is accompanied by a sense of urgency which amounts to pain, and, when the act of micturition finishes, the contraction of the tender trigone may produce pain which is distributed to the neck of the bladder, to the rectum, and to the point of the penis.

The urine contains pus in varying quantity; in addition there is mucus and bacteria, and in severe cases blood may be present. The reaction of the urine has been alluded to.

EXAMINATION. In investigating a case of cystitis in a child, the examiner must ascertain whether the infection is confined to the bladder wall or whether it is secondary to renal disease. The question is decided by a careful general examination, by special investigation of the kidneys, by a detailed examination of the urine, and by cystoscopy.

TREATMENT. Any exciting cause which may exist must first be recognized and treated.

In the *acute catarrhal stage* of the infection the child should be confined to bed, and the diet restricted to milk and eggs, custard, soup, and light farinaceous foods. Large amounts of bland fluids are given, particularly barley water. If there is much pain a hot fomentation containing laudanum is applied over the lower abdomen, a hot sitz-bath is given, and a morphia suppository is inserted.

If the urine is acid, immediate improvement will follow the administration of alkali (citrate of potash and bicarbonate of soda). To reduce painful spasm of the bladder, tincture of belladonna and tincture of hyoscyamus may be given.

In *chronic cystitis* the problem of treatment is a more difficult one.

a 'hands and knees' attitude. The assumption of this position is often characteristic of the disease.

Hæmaturia This feature, so frequent in the adult, is uncommon in the child.

Cystitis Inflammation of the bladder wall ultimately develops, and with its appearance there is an exaggeration of the previous symptoms—the pain and frequency of micturition increase, there is constant straining, and the urine contains pus.

Prolapse of the rectum is a frequent accompaniment of bladder stone, it is the result of frequent straining.

EXAMINATION The methods pursued in the adult are followed in the child. The existence of the stone is demonstrated by sounding and by cystoscopic examination. If the stone is large it may be possible to feel it by a combined abdominal rectal palpation. The examination should be carried out under anaesthesia.

TREATMENT The stone should be removed by the operation of supra pubic cystotomy.

TUMOURS OF THE BLADDER

Tumours of the bladder are rare in children, and those which occur are generally of the connective tissue type, such as spindle celled sarcoma and fibro sarcoma. These tumours generally appear in the form of polypi attached to the base of the bladder. The villous papilloma of the adult is exceedingly rare in the child.

SYMPTOMS AND SIGNS Dysuria, incontinence of urine, and pain in the lower abdomen are the early symptoms of the disease. Hæmaturia then appears, and is copious in amount. Cystitis next develops, and with it there is the usual exaggeration of symptoms.

The tumour may be palpable *per rectum*. Its position and characters are apparent on cystoscopic examination.

TREATMENT The outlook is extremely grave, and early death is usual. In certain rare cases where the growth is localized, extirpation may be attempted, but in the majority of cases the treatment is symptomatic.

In a considerable proportion of cases the bladder lesion thereafter recovers.

When the disease is the result of bilateral tuberculosis, or if it has been the result of genital tuberculosis, the treatment must be of a general and symptomatic nature. Residence in a dry warm climate is advised. Plain and nourishing food is given in abundance, tuberculin may be given a trial, and the bladder spasms are reduced by belladonna and hyoscyamus. In particularly severe cases a supra-pubic cystotomy may be done, and local applications tried. Of these the best is 5 per cent. iodoform in liquid paraffin.

STONE IN THE BLADDER

The common age period of stone in children is from about the second to the seventh year. The reason for this comparatively early incidence is the fact that concentrations of uric acid are most apt to appear in the early days and weeks of life, and it is at this period that the nuclei are formed upon which calculi of pathological size are developed.

The great majority of bladder stones in children are therefore renal in origin, and composed of pure uric acid as far as their centres are concerned. Upon this basis, oxalate of lime, calcium phosphates, and ammonia-magnesium-phosphate may become deposited. A noteworthy point is the small part which infection plays in the formation of bladder stone. The disease is much more frequent in boys than in girls.

SYMPTOMS. The symptoms of the disease are more obscure in the child than in the adult. There are various reasons why this should be so—the possibility of stone in the young subject may not arise in the surgeon's mind, the child may have difficulty in describing subjective symptoms, and certain reflex phenomena may occur which are somewhat misleading. Pain, disorders of micturition, hæmaturia, and cystitis are the usual signs.

Pain. Intense pain may be absent, or it may be spasmodic in type, so that the child screams in his distress; sometimes there is severe abdominal pain with vomiting, the picture simulating an acute abdominal disturbance. When the pain is present the child is often observed to carry out a movement which is highly characteristic—he grasps the penis and prepuce and drags upon them. The pain is usually distributed to the bladder, the perineum and the front of the penis.

Disorders of Micturition. There is frequency of micturition which may become a true incontinence, and this feature is present during both night and day. An involuntary arrest of micturition may occur if the stone becomes displaced into the bladder neck. Micturition is painful at both the commencement and the termination of the act, but the child learns that the distress is lessened if he gets into

CLINICAL FEATURES

It is evident that, if the preputial orifice is abnormally small, an increased effort will be necessary to expel the urine—straining, therefore, is one of the most constant features. Secondary to the straining the young child may develop such disorders as hernia and prolapse of the rectum.

Balanitis sooner or later appears, it gives rise to local irritation, discomfort, and pain, during the acute stage there may be reflex retention of urine. More important, however, than the local signs are the more general reflex changes which are secondary to the balanitis—nervous irritability, sexual irritation, incontinence of urine, and even such a condition as persistent flexion of the hip muscles, simulating hip-joint disease.



FIG. 451.—Phimosis

Reduction of the foreskin is impossible owing to the narrowness of the preputial orifice.

Repeated and long standing balanitis may result in the deposit of preputial phosphatic calculi, and these greatly accentuate the irritation which exists.

EXAMINATION OF THE CASE

An attempt at retraction of the foreskin will demonstrate the degree of phimosis which exists. A distinction must be drawn between true phimosis and the condition in which there is a long loose prepuce without any actual narrowing of the preputial orifice. It should be noted whether any balanitis exists at the time of examination, and the investigation should include the hernial rings, the cord, and the testes.

CHAPTER XXXVI

SURGERY OF THE GENITO-URINARY SYSTEM

(continued)

DISEASES OF THE GENITAL ORGANS

PHIMOSIS

Phimosis is a very frequent occurrence. The term implies such a narrowing of the preputial orifice that the foreskin cannot be retracted over the glans.

ETIOLOGY

The majority of cases are congenital in their origin, but under certain conditions an acquired phimosis appears—for example, repeated attacks of balanitis may result in a ring of cicatricial tissue surrounding the opening of the prepuce. Similarly, a traumatic phimosis may follow injury, ulceration, or an incomplete circumcision.

PATHOLOGY

The degree of phimosis varies within wide limits—the most extreme forms are seen in the varieties which follow injury or ulceration. There is a varying degree of adhesion between the mucous membrane which covers the glans penis and that lining the inner surface of the foreskin. The adhesions are most complete in the congenital types.

In the fossa behind the corona a quantity of smegma collects in soft white deposits. From time to time irritation is liable to appear, balanitis develops, a foul-smelling liquid secretion collects below the foreskin, and there is congestion and œdema of the foreskin and the soft tissues of the penis. One attack of balanitis is liable to be followed by others.

The length of the foreskin is a matter of importance. If it is long with a narrow preputial orifice, urine dilates the preputial sac at each act of micturition, and a certain degree of stagnation of urine occurs; the complication of balanitis is always more common and more intense in this variety of the deformity. A phimosis is usually associated with an abnormal shortening of the frænum.

couple of straight bayonet pointed needles, and some No — 000 ordinary catgut

The tip of the prepuce is picked up in the dissecting forceps, and the foreskin is pulled forwards from the glans. The Kocher's artery forceps is now applied in a slightly oblique direction downwards and forwards immediately in front of the glans penis—there is no danger of the glans being included in the grip of the forceps, but its exact position should be ascertained before the forceps is applied. The handles of the Kocher's forceps are now tilted forwards so as to pull the foreskin away from the glans, and with a sharp knife the foreskin is divided immediately on the central side of the forceps. In order to prevent injury to the glans the knife edge should be kept directed towards the forceps. When the foreskin is removed two cut and bleeding surfaces of tissue are exposed—the outer skin surface, and within it, usually contracted to a considerable extent, the divided subpreputial mucous membrane. Through the contracted cut surface of the latter the glans penis is apparent.

The cut skin surface at once retracts, but the mucous membrane remains *in situ*, and a raw bleeding surface opens up between the two. Picking up the cut surface of the mucous membrane, one blade of the sharp pointed scissors is inserted between the glans and the cut mucous membrane which is now divided dorsally in the mid-line. This division should not include the overlying skin, and the beginner must be careful that the scissors blade is inserted in the proper place. It has occurred that one blade of the scissors has been inserted into the urethra instead of into the sub mucous space. With division of the mucous membrane, it is now possible to grasp the cut edges and to separate it from the glans penis, this is difficult or easy, according to the amount of adhesion. It is important that the separation be carried back to behind the corona, as it is in this space that the smegma collections lie, and it is essential that these be completely cleared out. If the Kocher's artery forceps have been applied correctly, no further removal of skin surface is necessary, but some trimming of the mucous surface will be required—the corners at each side of the median dorsal incision are rounded off, and, if necessary, a thin collar of tissue is removed. This latter is very rarely indicated—in fact, every care should be taken not to remove too much of the mucous membrane, as it may result in an ugly contraction. A perfect circumcision is one in which the muco cutaneous junction lies just in front of the corona of the glans, and is sufficiently loose to permit of further retraction.

Bleeding from the small divided vessels in the space between divided skin and mucous membrane is controlled by force pressure and ligation, the hæmostasis must be complete, or a hæmatoma forms which jeopardizes the success of the operation. It is important to employ a fine ligature, as the knots of a thick catgut are unstable. The operation concludes by uniting the cut edges of

TREATMENT

We believe that it is necessary to enter a word of warning against the too general practice of circumcision. There is a type of individual who, quite apart from any religious views which he may hold, advises the operation on the slightest pretext. This attitude is wrong. The foreskin has a distinctive and specific function, and circumcision should only be recommended for definite reasons.

Indications for Operation.

Operation is indicated—

- I. If there is such a preputial narrowing that it is impossible to retract the foreskin completely. Complete retraction is required for proper hygiene of the part, and such hygiene is essential in every male child.
- II. If there has been any balanitis.
- III. If paraphimosis has occurred.
- IV. If there are reflex conditions existing which may be ascribed to an irritation of the glans.

The Choice of Operation. There are two methods at the surgeon's disposal—stretching of the preputial orifice and circumcision. The advantages of the former are questionable. It has the serious disadvantage that it is liable to produce a fibrous contraction of the prepuce, and therefore an exaggeration of the phimosis. The method should be reserved for new-born children who show a tendency to preputial contraction. At that time, without any administration of an anæsthetic, the prepuce is fully stretched by separating the blades of an artery forceps, and, if from this time onwards the foreskin is regularly retracted and attention is paid to the hygiene of the subpreputial space, subsequent circumcision may be avoided.

Circumcision. If operation is indicated, this, in the majority of cases, is the method of choice. There are many ways of performing the operation, but we shall restrict ourselves to describing the method which we have made our routine, and always with satisfactory results

Careful local sterilization of the part is carried out. The child is placed in such a position that his legs hang over the end of the table, the operator standing or sitting opposite the penis. Chloroform is the anæsthetic of choice, and the operation should not be begun until the child is completely under; the operation is associated with powerful reflex responses, and many anæsthetic disasters have resulted from beginning the operation before anæsthesia is complete.

Only a few simple instruments are necessary—a toothed dissecting forceps, a plain dissecting forceps, a Kocher's artery forceps, several pairs of fine artery forceps (Crile's pattern), a knife, fine scissors, a

undergoes decomposition, and the subsequent irritation produces ulceration, the absence of the protecting prepuce permits of slight trauma, which further devitalizes the part.

The complication is treated by keeping the meatus as dry as possible, and by the application of a small quantity of adrenalin and cocaine ointment or zinc ointment. If simple measures fail, a thin bladed scalpel is passed into the meatus, and the ulcer is divided upwards and downwards for a depth of about $\frac{1}{8}$ inch. It is a further advantage to keep the surface of the meatus apart by inserting a horse hair stitch on each side, the stitch passing into the meatus for about $\frac{1}{2}$ inch and then through the glans, appearing on the surface behind the corona. Each stitch is tied on the outer side of the glans. The stitches are kept in position for four days.

3 *Contraction of the Foreskin* If an insufficiency of skin has been taken away the cut surface contracts, and a secondary phimosis develops. The complication is avoidable, but, if it develops, it demands a second operation.

The mistake of removing too much skin leads to an even more troublesome complication. The contraction of the skin produces a tense mucous surface, which extends from the cut surface of the skin to the corona. This area, being continually under tension, is liable to remain persistently irritated or even ulcerated. The only way to correct the condition is by making a circular incision round the penis which only passes through the skin. A cuff of skin is thus mobilized, which can be slipped downwards so as to correct the error. The area from which the skin has been displaced is allowed to granulate.

PARAPHIMOSIS

If the preputial opening, though narrow, is sufficiently wide to permit of retraction of the foreskin, and if, after retraction, there is difficulty in restoring the foreskin to its correct position, the condition is termed paraphimosis.

ETIOLOGY Children sometimes amuse themselves by retracting the foreskin, and to their alarm find that they are unable to restore it. It may be that balanitis is present and, to gain relief from an irritation, the child retracts the foreskin. Edema is already present, and paraphimosis is thus quickly established. Children who practise masturbation are liable to develop the condition.

PATHOLOGY At first the retraction of the foreskin gives rise to a somewhat pleasurable sensation, but if the displacement is permitted to remain, pressure begins to be exerted upon the venous return, and edema of the penis develops. A vicious circle is quickly established, for, as the penile edema becomes more marked, tension of the foreskin behind the corona naturally increases. If the condition is neglected, the disparity between the oedematous glans and the tight

skin and mucous membrane. This may be done by continuous or by interrupted sutures—we prefer the latter; the former tends to become rather of a purse-string nature, and it prevents the escape of blood between sutures. Catgut, horse hair, or silkworm gut may be employed as the suturing medium. Catgut is the most suitable for young children; it is sufficiently strong, and the removal of suture is avoided. In children above the age of seven horsehair or silkworm gut should be used, as an erection of the penis may occur, and the catgut may give way.

METHOD OF DRESSING

A narrow bandage of sterile gauze soaked in hydrogen peroxide is applied as a collar around the penis. It is applied so as not to occlude the opening of the urethra. Hazeline ointment forms an excellent dressing, and it is the one which we prefer for babies in whom the small size of the penis prevents the application of a circular dressing. Sterile gauze is smeared with the ointment, and a fresh pad is applied after each micturition. A useful method in out-patient work is that of tying on the dressing. If this plan is adopted the skin and mucous surfaces are united with a series of interrupted catgut sutures, the ends of which are left long after tying; a roll of sterile gauze about the thickness of a cigarette is placed round the suture line so that it lies within the compass of the sutures, and each suture is tied a second time so as to include the gauze roll. It will be found that the method keeps the dressing in position, while, the meatus being free, there is little tendency for the dressing to become contaminated. With care it can be kept in position until the wound is healed, when the dressing separates as the catgut sutures are absorbed.

POST-OPERATIVE COMPLICATIONS

1. *Hæmorrhage.* Care should be exercised in the ligature of the vessels, and especially in dealing with the frænal artery. It is a humiliating experience to find a large hæmatoma developing which could have been prevented if care had been taken. If the bleeding is excessive it will be necessary to open up the wound and to tie the bleeding point. In less marked bleeding the application of pressure and a liquid hæmostatic such as adrenalin (1 in 1,000), hæmoplastin, or coagulin ciba, may prove sufficient.

2. *Meatal Ulcer.* It may happen that a circumcision which appears to be completely successful is followed by the development of pain on micturition. When the meatus is examined it is found that a shallow circular ulcer surrounds the opening, the irritation of this being responsible for the pain. The ulcer produces a quantity of purulent material, which tends to seal up the meatus, and so may give rise to acute retention. The ulcer arises because after micturition a small drop of urine tends to lie in the opening of the meatus, the urine

surfaces of the prepuce are present, and they may be so redundant as to form a hood covering the glans. The glans is flattened and expanded, and it is sometimes bent at an angle to the body of the penis. The urethra anterior to the fistula is usually represented by a shallow groove on the under surface of the glans—in a few cases even this trace is indistinguishable. In a very small proportion the glans is tunnelled.

The *penile type* is an exaggerated form of the balanic variety. The prepuce is well formed, and its postero lateral edges blend with the adjacent scrotal tissue so as to form folds resembling miniature labia. The glans has characters very similar to those found in the balanic type. The fistulous opening exists on the under surface of the penis, anterior to the opening there is a groove which extends forwards to the margin of the glans. The scrotum is well developed and the testes are descended.

The *perineal type* is distinctive. The scrotum is cleft and the testes may be retained. The opening of the urethra is a little in front of the anus, anterior to this point the urethra is represented by a shallow groove on



FIG. 452.—Hypospadias (Boy 3½ years).
An example of peno scrotal hypospadias. The scrotum is split.

the under surface of the penis. The body of the penis is usually bowed down in a curved attitude.

This, the most severe type of the deformity, is analagous to the phallic groove met with in the cloacal penis of the tortoise and marsupials, it has an aspect of considerable social importance, as subjects of the deformity are often mistaken for hermaphrodites, or they may be brought up as girls until the changes of puberty disclose their true sex.

ETIOLOGY—EMBRYOLOGY The cause of the deformity is a lack of formation of normal structures or an arrest of development. At an

encircling prepuce may become so extreme that even the arterial supply to the part is interfered with, and gangrene may ensue. Fortunately this is rare.

CLINICAL SIGNS. At first there is alarm and mental distress. Local discomfort is soon felt, and as the tension increases the pain becomes very considerable. There may be retention of urine, but the difficulty is at first reflex, and it is only in the extreme stages of the condition that the tension is so great as mechanically to occlude the urethra.

TREATMENT. The treatment consists in a reduction of the displacement: at first an effort should be made to reduce without the aid of incision of the part. The glans is washed over with a weak antiseptic, and the surface is coated with sterile vaseline. With the left hand controlling the constricting ring, the glans is gently manipulated with the fingers of the right hand, and the prepuce is coaxed over the glans. If the oedema of the glans is marked, firm pressure between the fingers will diminish it, and reduction may then be possible.

If manual reduction fails, the constricting ring should be divided on the dorsum with a sharp scalpel.

It is sometimes advised that circumcision should be done as an immediate treatment for paraphimosis. This is a mistake—the tissues are cedematous and devitalized, and healing by primary union is unlikely. It is better to reduce the error by either of the methods described above; when the tissues have returned to normal, a circumcision may be done.

HYPOSPADIAS

Hypospadias is a congenital error characterized by an abnormal opening of the urethra on the under-surface of the penis, and by an absence of some part of the lower or posterior wall of the urethral canal.

Varieties. Three varieties of the deformity are described:—

- (1) The *balanic* or *glandular form*, in which the urethra opens immediately behind the margin of the glans.
- (2) The *penile form*, in which the opening exists on some point of the under-surface of the penis anterior to the peno-scrotal junction. If the fistula lies at the junction of penis and scrotum, it is spoken of as the *peno-scrotal* variety.
- (3) The *perineal form*, in which the urethral opening is near the site of the central point of the perineum.

Characteristics of the Different Varieties.

The *balanic* type is the most common; its incidence is about one in five hundred male children. The urethral opening exists in the position which the frænum would normally occupy, for the frænum and the under-surface of the prepuce are absent. The lateral and upper

When the child reaches adolescence and begins to appreciate the existence of the deformity, there may be a good deal of mental disturbance, and in later life this aspect of the condition may be serious.

DIAGNOSIS The only difficulty which may arise in connection with diagnosis is the distinction between the perineal type of hypospadias and hermaphroditism. In the latter it is possible to demonstrate the existence of a vagina, while on rectal examination the imperfectly developed uterus is felt.

The slighter degrees of balanio hypospadias may approximate so closely to the normal that they are overlooked by a careless examiner.

PROGNOSIS If left alone, hypospadias remains without change throughout life. The operative prognosis is good in the balanio variety, and in the slighter degrees of the penile type. In the perineal type the deformity may be so extreme as to preclude any attempt at operation.

TREATMENT

For obvious reasons operation should be recommended if the case is in any way suitable. The difficulties and uncertainties of the operation should be explained to the parents, but the great advantages of a successful attempt should be made clear to them. Before operation is attempted certain general considerations must be taken into account—these are—

- (1) Age
- (2) The general condition of the child
- (3) The question of a preliminary cystotomy

(1) *Age* It is our practice to delay operation until the child is four years old. If the operation is done during infancy the organs are so small and so delicate and the difficulties of keeping the parts clean are so numerous that failure is likely to ensue. In the serious types of perineal and scrotal hypospadias we delay interference until the eighth or tenth year. If the intended operation is to be a two stage one, the first stage may be carried out at an early age, the importunate parent may often be satisfied in this way.

(2) *General Condition* It is an essential condition that the child be in good general health at the time the operation is undertaken. To operate upon a bad subject is to court failure. The urine must be normal, and free from any pathological content.

Where hypospadias is associated with cryptorchism or other congenital deformities, it is very doubtful whether operation should be attempted.

(3) *Preliminary Cystotomy* The advantages of a preliminary cystotomy, supra pubic or perineal, appear to be considerable because the side tracking of the urine favours healing. Our practice has been to advise a preliminary perineal cystotomy in the penile and peno scrotal types, and a supra pubic operation in examples

early stage of development there is no genital distinction between male and female. About the sixth week of embryonic life the arrangement is common to both sexes, that at the lower end of the embryo there is a depression (the cloaca) which corresponds to the opening of the gut and the bladder. After this period, distinction begins by the formation of the *genital ridge*, which develops around the anterior part of the depression, and quickly becomes modelled into a central prominence (the *genital eminence*) grooved on its under-surface (the *genital groove*) and flanged on each side by lateral folds (the *genital folds*).

The genital eminence becomes the penis of the male and the clitoris of the female, and from the third month onwards the sex distinction becomes apparent. In the male the genital eminence enlarges laterally to form the *corpora cavernosa*, the median groove on the under surface



FIG. 453.—Hypospadias of the Perineal variety (the scrotum is divided) (Child 14 months old).

thereby deepening to form the future urethra. The genital folds, which in the female remain distinct as the labiæ and the nymphæ, in the male merge into each other to form the scrotum, the line of fusion persisting as the median raphe.

It is apparent from this short description that, if there is a failure in union of the genital folds either wholly or in part, a deficiency results in the floor of the urethra which constitutes the condition of hypospadias.

CLINICAL FEATURES. In minor degrees of hypospadias, the act of micturition is troublesome because the stream is misdirected. Frequency of micturition and true incontinence may accompany the deformity. In the penile and perineal types the child prefers to urinate in a squatting position, or to manipulate the urethra by pulling on it and thus straightening it so that the stream is directed forwards.

found to have disappeared. The beginner will probably be alarmed to find that complete correction has resulted in a considerable recession of the urethral orifice, but the distortion is more apparent than real.

The opposing edges of the incision are united with interrupted silk worm gut and horseshair sutures, and the penis is fastened in such a position on the front of the symphysis and lower abdominal wall that the correction is maintained.

It is our practice to allow some weeks to elapse before passing on to the second stage of the operation.

Making the new Urethra. The variety of methods which have been suggested and practised in connection with this stage of the operation is so great that it is impossible to mention all of them in detail.

Three types of operation have been employed —

- (1) Dissection of the urethra from its bed and implantation of it through a tunnel formed in the glans.
- (2) The employment of flaps obtained from the prepuce and the side of the penis.
- (3) The transplantation of extraneous tissue such as vein or appendix to replace the absent urethra.

The description which follows is confined to those methods which we employ and which we have found of value.

Operation for Balanic and anterior Penile Forms of Hypospadias

If the deformity is a slight one, and there is little penile deformity, we practise the method associated with Beck's name.

Dissection of the Urethra from its Bed and Implantation of it into the Glans. A circular incision is made around the opening of the urethra, and a vertical cut is carried backwards along the under surface towards the perineum. The urethra with the *corpus spongiosum* is dissected off the underlying tissue, and the separation is continued backwards until sufficient length has been secured. The tissue outlined by the circular incision around the urethral opening is dissected free, and care should be taken to have a sufficiency of it, as the urethral length available is thus increased. The distal end of the penis and the glans are tunnelled by a thin bladed scalpel, the detached urethra is drawn through the tube, and the bell shaped end is sutured to the edges of the opening of the tunnel in the glans with fine horse-hair. A lubricated probe is now passed along the transplanted channel, and the new opening is covered with sterile vaseline—these precautions are intended to prevent closure of the orifice with blood clot and a retention of urine which may endanger the success of the operation.

We have found this method satisfactory, and it has the particular advantage that it does not demand a preliminary cystotomy.

If there is much deformity of the penis, and if the urethral opening

of the perineal type. Our experience has been that success can rarely be assured unless a preliminary drainage is arranged for. In the balanic variety a preliminary operation is unnecessary.

• Many surgeons believe that, in the more extreme forms, if the closure of the abnormal outlet is delayed until the last stage of the operation, all the other stages being completed first, cystotomy is unnecessary.

Essentials to Success. These are so well defined that they may be presented *seriatim* :—

- (1) Hair-bearing skin must not form any portion of the new urethra. The growth of hair becomes the site of phosphatic deposits, and great distress is thereby caused.
- (2) All intra-urethral sutures should be of fine horsehair or of chromic catgut. They do not demand removal: they slough out and are passed. Sutures of ordinary catgut are bad—the catgut swells and loosens, the stitch holes are infiltrated with urine, infection follows, and the wound breaks down.
- (3) Good and exact suturing is essential. Leakage between sutures is the commonest cause of failure.
- (4) Considerable care is required in the post-operative treatment, which, as far as possible, should remain under the care of the surgeon himself.
- (5) The amount of post-operative scar tissue should be reduced to a minimum.

Choice of Cases. Examples of *perineal hypospadias* with associated cryptorchism are probably both sexually impotent and sterile. Apart from sentiment, there is no real reason to advise operation in these cases. On the other hand, if it is reasonably certain that sexual powers exist, the operation is imperative for the future happiness of the individual.

Doubt may exist as to the advisability of operating on the slighter degrees of the *balanic type*. If the imperfection is slight, and if the penis is reasonably straight and well-formed, operation is probably unnecessary. It is justifiable in the *penile* and *peno-scrotal* varieties.

METHODS. A successful operation on whatsoever plan it may be arranged has two objects—(1) to straighten the penis, and (2) to restore the continuity of the urethra.

Straightening the Penis. This procedure is essential if there is any bowing of the organ, a deformity which is greatly exaggerated during erection. Correction is secured by simple means. A transverse incision is made on the under surface of the penis at a point corresponding to the centre of the contraction, generally the summit of the concavity. The incision must be deep enough to divide every structure down to the *corpora cavernosa*. This may mean a large wound, for, as the transverse incision is deepened, it becomes transformed into an oblong, but, if the sides are now approximated, the bowing will be

the urethral opening, an oblong flap is outlined on the dorsum of the prepuce of such a length that its free extremity can be brought without tension through the tunnel up to the level of the urethral opening. The flap is converted into a tube by a series of interrupted sutures of fine chromic gut, the tube is carried along the tunnel and fastened in place at its point of exit on the surface. When the implantation has become consolidated in its new position (a period of about ten days) its preputial attachment is severed. After a further interval of ten days the proximal end of the implantation is united to the urethral opening.

The disadvantages of the method are the risk of sloughing of the tubular implantation, the multiple stage nature of the operation and the difficulty of uniting the graft to the urethra. It is this last point which has proved our stumbling block, a preliminary cystotomy is essential to success, and, even with this precaution, the risk of fistula formation is considerable.

The technique of the Russell Duplay operation is as follows. The penis is straightened, and a preliminary cystotomy (perineal) is done. After an interval

of ten days lateral flaps of skin and subcutaneous tissue are cut from the side of the penis and prepuce the flap outline is shown in the accompanying diagram. The anterior extremities of the flaps, as far back as the under surface of the glans, are dissected entirely free. *posterior to this point the edges only are separated in order that the blood supply may be assured.* The lateral edges are united with interrupted chromic gut sutures, and the mesial edges are similarly joined. A curved tube results, the anterior end of which is carried through a central tunnel as in the Mayo method. The

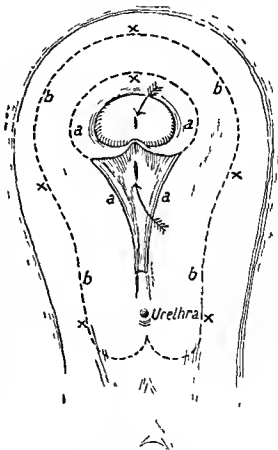


FIG. 456.—Perineal Hypospadias. The Russell Duplay method of closure.

is two centimetres or more behind the glans, transplantation of the urethra is unsatisfactory. The tension necessary to bring the urethra forward will probably result in sloughing of the tissue, and even if this is avoided the fore-shortening results in reappearance of the penile curve. Therefore in this type of case a plastic method is

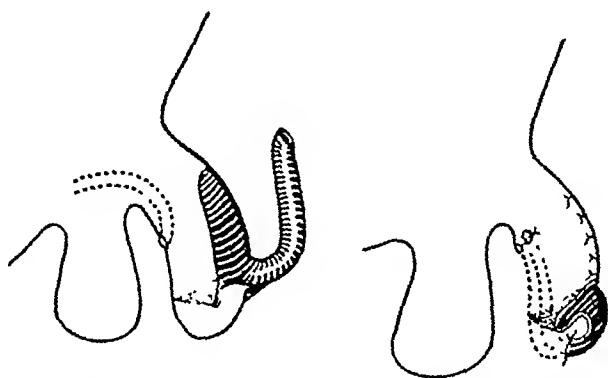


FIG. 454.—The “ Mayo ” Operation, designed to relieve a penile hypospadias.
(After Thompson.)

preferable, flaps being taken from the prepuce and the penis. In this class of operation one or other of two principles is followed—either the flaps destined to form the urethra are obtained from the dorsum of the prepuce, as in Mayo’s method, or the flaps are obtained from the sides of the penis (the Russell-Duplay operation). We have practised both

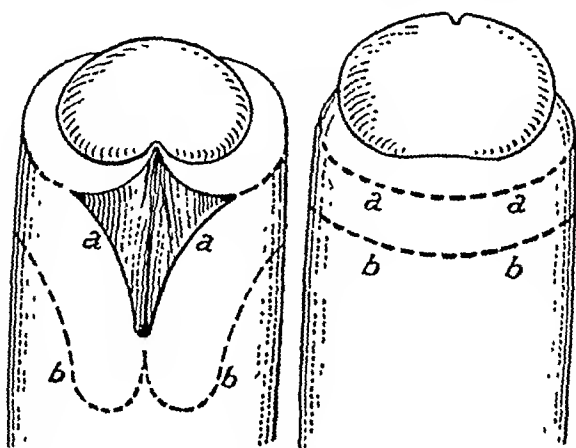


FIG. 455.—Penile Hypospadias. The Russell-Duplay method of closing the defect.
(After Thompson.)

of these methods, and our choice is rather in favour of the Russell-Duplay technique.

The details of the Mayo operation are explained by the accompanying diagram. After the penis has been straightened, an interval of some weeks is allowed to elapse to enable the parts to heal. The penis is then tunnelled from the centre of the glans to a point at one side of

the urethral opening, an oblong flap is outlined on the dorsum of the prepuce of such a length that its free extremity can be brought without tension through the tunnel up to the level of the urethral opening. The flap is converted into a tube by a series of interrupted sutures of fine chromic gut, the tube is carried along the tunnel and fastened in place at its point of exit on the surface. When the implantation has become consolidated in its new position (a period of about ten days) its preputial attachment is severed. After a further interval of ten days the proximal end of the implantation is united to the urethral opening.

The disadvantages of the method are the risk of sloughing of the tubular implantation, the multiple stage nature of the operation, and the difficulty of uniting the graft to the urethra. It is this last point which has proved our stumbling block, a preliminary cystotomy is essential to success, and, even with this precaution, the risk of fistula formation is considerable.

The technique of the Russell Duplay operation is as follows. The penis is straightened, and a preliminary cystotomy (perineal) is done. After an inter-

val of ten days lateral flaps of skin and subcutaneous tissue are cut from the side of the penis and prepuce, the flap outline is shown in the accompanying diagram. The anterior extremities of the flaps, as far back as the under surface of the glans, are dissected entirely free, posterior to this point the edges only are separated in order that the blood supply may be assured. The lateral edges are united with interrupted chromic gut sutures, and the mesial edges are similarly joined. A curved tube results, the anterior end of which is carried through a central tunnel as in the Mayo method. The

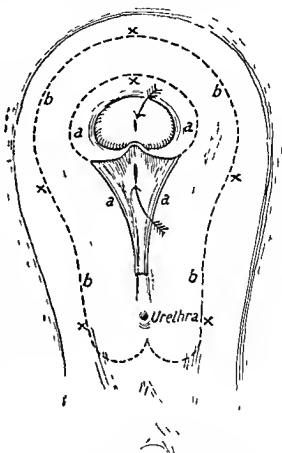


FIG. 406.—Perineal Hypospadias. The Russell Duplay method of closure.

operation is completed by uniting the remaining raw edges so as to cover over the implanted urethra.

The operation, as far as the urethral repair is concerned, is a one-stage method, and the blood supply is so free that sloughing is very unlikely. For these reasons we prefer the Russell-Duplay technique.

Operation for the Posterior Penile and Perineal Varieties

In these cases we employ a method similar to the Russell-Duplay operation already described. A preliminary supra-pubic cystotomy is required.

EPISPADIAS

If the child is born with a deficiency in the upper wall of the urethra the abnormality is termed an epispadias. It is sometimes described as a median fissure of the anterior wall of the urethra. The error is one of considerable rarity, and, while it may occur in either sex, the incidence is mainly in boys.

ETIOLOGY. The developmental error responsible for the deformity arises in connection with the genital eminence, the tissue from which the penis and clitoris develop. Originally the eminence develops as two independent tubercles, each of which is concerned with the formation of half of the fully developed organ. If for any reason the fusion of the original tubercles is incomplete, epispadias results. It is supposed that an abnormal forward development of the anal plug is the mechanical explanation of the imperfect union of the genital tubercles.

CLINICAL FEATURES

The clinical manifestations vary according to the sex of the individual, and to the variety of the malformation.

Epispadias in the Male. It is convenient to divide the deformity into three groups:—

- (1) Peno-pubic epispadias.
- (2) Penile epispadias
- (3) Balanic epispadias.

Peno-pubic Epispadias. This is the most common variety, and in a modified way it always accompanies extroversion of the bladder. It is sometimes spoken of as 'complete epispadias.' The penis is small, flattened, and spatula-like in outline, a broad gutter marks the upper surface, and when the organ is pulled outwards the gutter is found to be continued backwards until it disappears in the infundibular space at the root of the penis. If the tip of the finger is introduced into this space the orifice of the internal meatus is felt. The infundibular space is arched over with a band of fibro-eutaneous tissue, the extremities of which unite with the root of the penis and the scrotum. The *corpora*

carinosa are imperfectly developed, the prepuce is redundant, and hangs as a triangular fold beneath the glans.

Associated with this type of the deformity may be separation of the pubis, extroversion of the bladder, and undescended testes.

Penile epispadias In this variety the dorsal groove traverses the entire length of the penis, but does not reach the neck of the bladder. The musculature of the internal sphincter is fully developed.

Balanic epispadias This form is characterized by an abnormal opening of the urethra on the dorsal aspect of the penis at the base of



FIG. 457 — Epispadias (Boy 2 years)

the glans. Distal to the opening the urethra exists as a broad shallow gutter.

Epispadias in the Female Epispadias in the female is characterized by absence of the anterior commissure of the vulva, the existence of a fissure separating the prepuce and glans of the clitoris into halves. The urethra is deficient on its upper surface, and the mucosa of the bladder may prolapse through the opening.

Incontinence is invariably present in the more extreme forms of the disorder, and it may occur even in the minor degrees. The surrounding skin becomes tender and irritated, and altogether the condition causes great distress.

TREATMENT

Many types of plastic operation have been designed. The success of any procedure must be judged by its ability (1) to relieve the urinary

operation is completed by uniting the remaining raw edges so as to cover over the implanted urethra.

The operation, as far as the urethral repair is concerned, is a one-stage method, and the blood supply is so free that sloughing is very unlikely. For these reasons we prefer the Russell-Duplay technique.

Operation for the Posterior Penile and Perineal Varieties

In these cases we employ a method similar to the Russell-Duplay operation already described. A preliminary supra-pubic cystotomy is required.

EPISPADIAS

If the child is born with a deficiency in the upper wall of the urethra the abnormality is termed an epispadias. It is sometimes described as a median fissure of the anterior wall of the urethra. The error is one of considerable rarity, and, while it may occur in either sex, the incidence is mainly in boys.

ETIOLOGY. The developmental error responsible for the deformity arises in connection with the genital eminence, the tissue from which the penis and clitoris develop. Originally the eminence develops as two independent tubercles, each of which is concerned with the formation of half of the fully developed organ. If for any reason the fusion of the original tubercles is incomplete, epispadias results. It is supposed that an abnormal forward development of the anal plug is the mechanical explanation of the imperfect union of the genital tubercles.

CLINICAL FEATURES

The clinical manifestations vary according to the sex of the individual, and to the variety of the malformation.

Epispadias in the Male. It is convenient to divide the deformity into three groups:—

- (1) Peno-pubic epispadias.
- (2) Penile epispadias.
- (3) Balanic epispadias.

Peno-pubic Epispadias. This is the most common variety, and in a modified way it always accompanies extroversion of the bladder. It is sometimes spoken of as 'complete epispadias.' The penis is small, flattened, and spatula-like in outline, a broad gutter marks the upper surface, and when the organ is pulled outwards the gutter is found to be continued backwards until it disappears in the infundibular space at the root of the penis. If the tip of the finger is introduced into this space the orifice of the internal meatus is felt. The infundibular space is arched over with a band of fibro-cutaneous tissue, the extremities of which unite with the root of the penis and the scrotum. The *corpora*

HYDROCELE

The differentiation of hydroceles into primary and secondary types of the disease is applicable to the child, but the great majority of the cases which one sees are examples of the primary type—that is to say, there is no associated disease of the testes or epididymis

Primary Hydrocele To appreciate the varieties of primary hydrocele it is necessary to recall that the testis in its descent from the abdomen into the scrotum is preceded by a finger-like process of peritoneum (the processus vaginalis). At birth the portion of the process extending from the internal ring to the upper portion of the testis is normally closed and obliterated, the lower portion remains as the tunica vaginalis testis. The accumulation of serous fluid within any portion of this tract, whether within the cavity of the tunica vaginalis or within a portion which normally should become obliterated, constitutes a hydrocele

VARIETIES The various forms of hydrocele recognized are —

- (1) Vaginal
- (2) Congenital
- (3) Infantile
- (4) Encysted hydrocele of the cord

The *vaginal type* is that in which an accumulation of serous fluid distends the cavity of the tunica vaginalis. A hydrocele developing a few days after birth is usually of this variety, its development being explained by injury which the testis has sustained during the process of birth. The development of a hydrocele of this type in later life should arouse suspicion that it is secondary in type, and indicative of an infection of the underlying testis

Congenital or Intermittent Hydrocele If the cavity of an unobliterated processus vaginalis retains a communication with the abdominal cavity, and the communication is large enough to permit the entrance of fluid yet is small enough to prevent prolapse of the intestine, a congenital or intermittent hydrocele results. The swelling has all the characters of an ordinary hydrocele, but it is subject to variations in size while it is reducible under pressure. Its bulk increases during the day and diminishes at night when the child is lying down, it may disappear entirely for long periods. A hydrocele of this type is often met with in association with tuberculous peritonitis

Infantile Hydrocele The pathology of this type is similar to that of the congenital variety except that there is no communication with the abdominal cavity. The result is a pear shaped fluid swelling often considerable in size

Encysted Hydrocele of the Cord When an isolated portion of the processus vaginalis remains unobliterated in the length of the spermatic cord an accumulation of serous fluid within the space constitutes a hydrocele of the cord. It appears as a rounded swelling in the length

incontinence (2) to change the point of exit and therefore the direction of the urinary stream, and (3) to improve the shape of the penis.

The operation associated with Cantwell's name is that which has met with the greatest measure of success. The technique is virtually dependent on the fact that in this disease the corpora cavernosa are capable of easy separation on account of the loose intervening attachment. Perineal drainage of the bladder is an essential preliminary; thereafter on each side of the gutter an incision is made along the junction of the mucosa and the skin extending from the pubis to the extremity of the glans, the incision extending down to the corpora



FIG. 458.—An example of Epispadias in the Female.

The anterior commissure is absent, and the bladder is apparent through the opening which exists where the urethra ought to be

cavernosa but not into them. The imperfect urethra is now freed from its bed, and the corpora are separated from one another until the skin on the lower surface of the penis is reached. The mobilized urethral flap is converted into a tube by means of a series of interrupted chromic gut sutures, it is laid in the lowest part of the intercorpal space, the corpora are brought together by a few interrupted sutures, and the skin edges are united.

Dellinger Barney has described successful results from a plastic procedure in which a flap from the redundant prepuce is transplanted to the dorsum of the penis so as to provide a roof for the imperfect urethra

When the complication occurs in the fully descended organ, there has usually been some sudden movement, as in swimming, to originate the displacement

CLINICAL FEATURES When torsion occurs there is severe local pain, the testis is swollen, hard, and tender to touch, the cord is swollen and oedematous, and a hydrocele develops in the tunica sac. Reflex vomiting may arise in the early stages of the error. If mechanical relief is delayed necrosis of the testis and epididymis supervenes.

DIAGNOSIS Torsion is liable to be confused with acute or sub acute orchitis, and with an irreducible or strangulated hernia. Orchitis is particularly difficult to exclude, in this event, however, the swelling is greater, and there is a primary focus from which the testis has become infected. Hernia is distinguished by the history and the local characters of the swelling.

TREATMENT Early operation is necessary if the torsion persists. There are many instances in which spontaneous reduction of the twist occurs, but, if pain and swelling continue, operation is necessary if the organ is to be preserved.

The cord is exposed by an incision over the external ring, the testis is dislocated from the scrotum, and the torsion is carefully undone. If necrosis has already occurred, the testis should be removed.

DISEASES OF THE TESTIS AND EPIDIDYMISS

The affections of the testis and epididymis which occur during childhood are very similar to those which one meets with during adult life. There are inflammatory infections both acute and chronic, and tumours, particularly sarcomata.

Acute Orchitis and Epididymitis

Acute infection of the testis proper—acute orchitis—arises during mumps, but this complication is practically unknown in children below the age of twelve years. During any acute disease which is associated with infection of the blood stream, an orchitis may appear as a local manifestation—thus we have observed it in cases of acute osteomyelitis, scarlet fever, and septicæmia. The infection quickly subsides under such simple local treatment as hot fomentations. Suppuration is a particularly rare event.

Acute epididymitis is exceedingly uncommon in children. It has been described as arising in association with acute cystitis, but the event must be a rare one.

Tuberculous Disease

Statistics show that tuberculous affection of the testis and epididymis is a disease of early childhood, the majority of the cases occurring during the first five years of life. The genital condition is usually the first manifestation of tuberculosis, it is uncommon in children who are already obviously tuberculous.

of the cord, but distinct from the testis with its coverings. Several swellings of this type may exist as a chain along the line of the cord. The tumour is mobile in all directions, but irreducible, and, if situated close to the external ring, it may simulate an irreducible hernia.

DIAGNOSIS. Two points of importance arise in connection with the diagnosis: (1) care must be taken to ascertain that the hydrocele is actually primary, and not secondary to a pathological condition of the testis, (2) the congenital type, the infantile type, and the hydrocele of the cord are apt to be mistaken for irreducible hernia. Careful examination and attention to the history should prevent mistakes.

TREATMENT. The vaginal hydrocele and the hydrocele of the cord do not demand operative interference unless their size is such that inconvenience is caused. The vaginal hydrocele may be tapped, but this procedure is not to be recommended for a hydrocele of the cord owing to the risk of a hæmatoma developing from puncture of the spermatic vein; it is wiser to expose the swelling and to remove it by dissection.

The congenital hydrocele should be operated on because of the likelihood of a hernia developing through the point of communication with the abdominal cavity.

The infantile type demands operation if its size is a source of discomfort.

In no event should operation be practised until the child is about six months old, because in a number of cases there is spontaneous absorption of the fluid and disappearance of the swelling.

The operation is similar to that performed in the adult. A small incision is made over the external ring across the long axis of the cord. The tissues of the cord are exposed and the hydrocele is made to prolapse through the incision. The sac is incised and emptied and a radical cure is guaranteed by the buttonhole method or by reversing the sac wall and suturing it behind the epididymis.

Excision of the sac wall is unnecessary; it is a procedure which may result in the formation of a troublesome hæmatoma.

Secondary Hydrocele. Secondary hydroccles are met with in association with tuberculous disease of the testis and epididymis, acute orchitis, and torsion of the testis.

TORSION OF THE TESTIS

Torsion of the testis is occasionally encountered during childhood. The complication is generally of a minor degree, torsion of such severity that necrosis of the organ results being uncommon.

Imperfect descent of the testis is a predisposing cause, because in this event the testis is unduly mobile, while it may be suspended by a mesenteric-like attachment—conditions which obviously predispose to torsion. The co-existence of a hernia is another predisposing factor.

Tumours of the Testis

The testis of the child is liable to become the site of a variety of tumours, many of which are of great interest to the histologist. The classification of new growths in this situation is a difficult problem, a few can be assigned to well recognized classes, a great number are so complex in their structure that classification is difficult or even impossible. A practical grouping of these tumours, as far as children are concerned, is one which recognizes three classes (1) Mixed tumours, (2) Teratomata, (3) Sarcomata.

(1) **Mixed Tumours** The embryonal development of the testis is such that inclusion of various extragenital tissues is liable to occur, and when this takes place mixed tumours may arise.

They develop in the body of the testis. They may exist at birth, or their appearance may become evident during the early years of childhood. The tumour is usually firm in consistency, and on section it reveals a medley of tissues of different types, cartilaginous or osseous or mucous, with vascular and connective tissues. At first the tumour appears to be stationary, a period of slow development supervenes which lasts for a year or two, and then a phase of rapid growth occurs which soon ends fatally. It seems that the phase of rapid growth is coincident with a malignant change in the tumour, because it is at this point that secondary invasion of the lumbar lymph glands occurs.

(2) **Teratomata** It is believed that teratomata of the testes arise from activity of the germ cells, the result of which is the production of composite tumours, it may be of considerable size. These tumours grow slowly, and during the period of childhood they rarely reach any considerable size. Their structure is peculiar, for, while they contain the basal elements of bone, cartilage, vascular and connective tissue, they also contain more highly specialized elements resembling thyroid, mammary gland, liver, or central nervous system.

The tendency to become malignant is not so marked as in the case of the mixed tumour, but there is the liability to sarcomatous change.

(3) **Sarcomata** These tumours are of a highly malignant nature, they develop in the body of the testis, their rate of growth is rapid, and in a comparatively short space of time they invade the epididymis or even ulcerate through the scrotal wall. Blood dissemination is an early event, and sarcomata in this region are associated with early secondary involvement of the lymph glands.

The spindle celled and the round celled are the forms which the tumour takes, the latter being more common. A rare variety is that in which the cells are perithelial in their arrangement (Krompecher's tumour).

TREATMENT In each of these varieties, early removal of the testis together with all the tissues of the cord is the only treatment.

PATHOLOGY. The epididymis is the site of origin, and the evidence suggests that the infection is blood-borne. The globus major or minor is first affected, the disease beginning as a group of characteristic tubercles, which rapidly undergo caseation and abscess formation. From the primary focus in the epididymis the disease may extend into the body of the testis, but the structure of this organ appears to render it peculiarly resistant to tuberculosis; the infection passes more readily along the vas deferens, where local caseating nodules appear along the length of the cord like a string of beads, or it invades the soft tissue of the scrotum, which undergoes abscess formation and bursts on the surface by a tuberculous sinus.

CLINICAL FEATURES. The disease often has an acute onset. In a young child the testis becomes the site of what apparently is an acute inflammatory reaction; this subsides in a few days, but it leaves a nodular swelling of the epididymis, which is recognized as a focus of tuberculous disease.

In other cases the process has a gradual beginning; the enlargement of the epididymis is so symptomless that it is unnoticed, and it is only when the testis and epididymis form a tumour mass or when a cold abscess appears that the nature of the condition is recognized.

In neglected cases the infection of the vas deferens spreads to the base of the bladder and a tuberculous cystitis results.

DIAGNOSIS. Tuberculosis is the only chronic disease of childhood which affects the epididymis. Syphilis and tumours affect the body of the testis. Further distinctive features of the tuberculous infection are the nodular outline of the disease focus, the secondary infection of the vas deferens, and the tendency to cold abscess formation.

TREATMENT. If the disease is confined to one side, removal of the affected tissue should be advised whenever the diagnosis is made. By this means it may be possible to restrict the removal of tissue to the epididymis. If there is any doubt as to the healthiness of the body of the testis it is wiser to remove the organ completely. In either event the vas should be removed as centrally as possible. The canal is opened, the vas is found, and by traction it may be possible to remove it to its full extent. General treatment must accompany the local procedure.

If the disease is bilateral, the surgeon is naturally unwilling to advise radical measures, but he should keep in mind the possibilities of partial epididymectomy.

Syphilitic Orchitis

Infants who suffer from congenital syphilis may develop a syphilitic orchitis. The characters of such a case are distinctive—the disease is usually bilateral, the testis is enlarged, hard, and painless, the epididymis may share in the swelling as a secondary event, and a hydrocele may appear. The condition disappears under anti-syphilitic treatment.

The aspects of the earlier stages of the condition are more medical than surgical, yet it would be misleading to present an isolated section of the clinical progress, and therefore a general consideration of the whole problem is presented

DEFINITION AND ETIOLOGY

The condition may be defined as an acute infective disease in which a peculiar inflammatory reaction affecting the grey matter of the central nervous system results in muscular paralysis of a flaccid type. The microbial origin of the disease at first defied demonstration, but the investigation of Noguchi and Flexner succeeded about 1913 in isolating the organism. It proved to be a 'globoid,' an ultra microscopical organism, so minute that it was capable of passing through the finest filter. The observers succeeded in cultivating the organism upon plasma media, and the fulfilment of Koch's law was obtained when injection of the organism into monkeys reproduced the disease, the organism being recovered from the infected animal.

The organism apparently gains entrance to the body through the mucous membrane of the nose, naso-pharynx, and possibly of the bowel. The infectivity of the disease is considerable—personal contact is the most frequent method of infection, but there is evidence that it is carried through the medium of flies, individuals may act as carriers though showing no clinical evidence of the disease.

The disease has a peculiar age incidence, it is rare in early infancy, it is most frequent during the period between the third and fifth years, and thereafter its frequency steadily diminishes.

In this country, at least, the disease has a seasonal incidence of some regularity, the period being the months of August, September, and October. Many countries have suffered from severe epidemics—in Scotland its prevalence has hitherto been sporadic—though occasional small outbreaks have been reported.

PATHOLOGY

While the serious signs of the disease proceed from the changes in the nervous system, a correct appreciation is one which regards poliomyelitis as a general disease. The organism gains entrance through the mucous membrane of the nose and naso-pharynx, and the high incidence of early childhood is partly at least explained by the existence at this age of numerous vascular and lymphatic channels through the base of the skull. If the organism has entered through the medium of the intestinal tract, the blood stream becomes the secondary path of infection. An acute toxæmia, possibly a septicæmia, inaugurates the illness, and at this stage the demonstrable pathological changes are those of cloudy swelling in the parenchyma of the viscera and evidences of infection throughout the body lymphoid tissues. In the early stages, the blood count shows a mild leucocytosis,

CHAPTER XXXVII

THE SURGICAL CONSIDERATIONS OF THE PARALYSES OF CHILDHOOD

There are various ways in which the paralytic diseases of childhood may be classified, but for practical purposes, and particularly from the point of view of treatment, it is satisfactory to adopt a grouping according to the anatomical site in which the error has originated. On such a basis the following varieties are recognized :

A. *Cerebral or Spastic Paralysis*, characterized by stiffness of joints and rigidity of muscles, by ataxia, by inco-ordination or loss of control of muscular movements rather than by actual loss of power, and explained by a destructive lesion of the upper motor neurone.

B. *Flaccid Paralysis*, as found in infantile paralysis, characterized by flaccid joints, by flabby paralysed muscles, and by a loss of control consequent upon the paralysis, the anterior horn of the grey matter of the cord being the site of the lesion.

C. *Peripheral Nerve Paralysis*, exemplified by the Erb and Klumpke types of paralyses of the upper extremity and the crural paralysis of the lower limbs—acquired conditions which usually proceed from injury, sustained at birth.

D. *The Paralysis which results from Muscular Dystrophies*—the myopathies.

E. *Congenital Paralysis*, the result of imperfect development of nerve fibres and characteristically seen in the paralysis which accompanies the more extreme forms of spina bifida.

In this chapter the first and second only of these various groups will be discussed.

Peripheral nerve paralysis is considered in connection with diseases of the extremities. The paralysis which results from muscular dystrophy has no surgical significance, except that it may necessitate the division of a tendon to relieve contraction. Congenital paralysis is discussed in relation to spina bifida.

I. INFANTILE PARALYSIS

It is difficult to over-estimate the importance of the scourge known as poliomyelitis or infantile paralysis, a disease which in the course of some hours may convert the healthy active child into a helpless cripple.

normally controls a muscle be affected there are others in the immediate neighbourhood which are healthy, and by educative methods it is often possible to induce the latter to assume the functions which their neighbours are no longer able to perform

CLINICAL FEATURES

In many instances the disease begins as an acute illness, the evidences of which are gastro intestinal or pulmonary, there may be vomiting and diarrhoea with nausea and abdominal pain, or signs of acute respiratory disorder. It is easy to appreciate how misleading these symptoms may be in the early diagnosis. In the majority of cases the signs are specifically referable to the central nervous system. The child is evidently acutely ill, the temperature is high, stiffness is complained of in the muscles of the limbs and neck. There is general hyperæsthesia and tenderness, a feature particularly important in the recognition of the case. Restlessness and mental irritability are noticeable, and there is often profuse sweating, apparently the result of a sympathetic stimulation. Some hours after the onset of the illness, the muscular paralysis becomes evident.

The disease is classified according to the site in which the disease occurs, and the varieties of paralysis which result. The arrangement suggested by Wickmann is generally adopted, it is as follows —

- (1) *Ordinary spinal paralysis*—isolated areas of the anterior cornua being the site of the infection
- (2) *Progressive or Landry's paralysis*—the infection beginning in the lumbar centre, spreading by an ascending infection to the upper reaches of the cord, and as a rule ending fatally by involving the medullary centres
- (3) *The acute encephalitic or spastic type*—the grey matter of the cortex being the site of the infection
- (4) *The ataxic type*—the result of foci of disease in the pons, medulla, mid brain, cerebellum, or Clarke's column
- (5) *The meningitic type*—in which inflammatory involvement of the pia mater is a prominent feature, and the symptoms resemble those of cerebro spinal meningitis
- (6) *The polyneuritic type*—the existence of this type has not been definitely proved, but on clinical grounds its retention as a distinct variety of the disease is justifiable
- (7) *The abortive type*—in which the disease subsides at an early stage and paralysis does not ensue

In practice it is often found that the disease is such a diffuse and variable process that there is no classification which includes all types—for example, there are many cases which lie between the abortive and the spinal types, cases in which there may be a slight temporary weakness of one muscle or group of muscles, or there may be merely a

the result of an increase in the lymphocytes ; the percentage of polymorphonuclear cells is diminished.

It is, however, in the tissues of the central nervous system that the main pathological interest lies, and it is convenient to describe the changes therein as occurring in a definite sequence.

An acute meningitis, both basal and spinal, is probably the introductory feature, thereafter the most adjacent cell matter, the posterior root ganglia, show congestive changes. This phase is one of clinical importance, because it explains to some extent the hyperæsthesia and tenderness which characterize the early stages of the disease. Hyperæmia of the cord now ensues, the lumbar enlargement being the area which shows the earliest and most marked changes. While the whole substance of the cord is involved, the changes are most marked in the vascular grey matter of the anterior horns. There is a peri-vascular infiltration of round cells with an accompanying œdema, and in certain areas the pressure on the vessel may be so great that there is occlusion with thrombosis. Small local hæmorrhages may appear, and there may be a general œdema of the cord. Coincident with the tissue changes the cerebro-spinal fluid shows peculiar features which are of importance in the diagnosis. The fluid is colourless, and as a rule shows no increase of pressure. During the first week or ten days there is an increase in the cell content—mononuclear cells of various types, and particularly lymphocytes. The globular content shows an increase, which is most marked about the third week. The fluid reduces Fehling's solution

The acute changes persist for a period of several weeks, and this is estimated in relation to the amount of pain complained of, for as long as peripheral tenderness exists an acute or sub-acute process is at work in the tissues of the central nervous system.

With the subsidence of the acute phase, changes supervene which are of equally serious import. The sites of the inflammatory exudates become areas of focal gliosis, and points of fibrosis develop which by their contraction exert a harmful pressure upon the nerve cells.

Interference with and destruction of the motor cells of the grey matter is the phase of most importance in the pathology, and according to the stage of the disease the detrimental influences vary in their character—the mechanical pressure of inflammatory exudates, the toxic influence of the organism, the anæmia which follows the occlusion of the vessels, the strangling effect of contracting gliotic or fibrous tissue, each in its turn exerts its harmful influence.

The appreciation of one aspect of the pathological picture is particularly important because it is so closely related to principles of treatment. Except in the rare progressive or Landry's type of the disease, the process is a focal and scattered one, isolated areas being picked out here and there. It is this feature of the pathology which underlies the treatment of muscle training, for if the cell group which

muscular paralysis, pathologically it corresponds to the processes of acute myelitis and meningitis

The Stage of Convalescence When tenderness disappears the stage of convalescence may be said to begin. It lasts for about two years, and, as judged from the pathological standpoint, it is the stage of resolution and the disappearance of inflammatory products. Clinically it is the period of recovery of power in the weakened muscles.

The Chronic Stage This period extends from the end of the second year throughout the remainder of life. Ghosis and fibrosis characterize the pathology, while clinically, affairs are either at a standstill or retrogressing.

DIAGNOSIS

It is only in the early stages of the disease that difficulties in diagnosis arise. Until the paralysis becomes evident, the disease resembles, and in fact is, an acute general infection.

Stiffness and tenderness in the muscles of the back with general irritability, signs which indicate an underlying meningitic infection, are suggestive.

With the appearance of paralysis, a further confirmation of the diagnosis is afforded. The tenderness which accompanies the muscular weakness is a distinctive feature, and examination of the cerebrospinal fluid affords the final evidence.

If the diagnosis has to be made at an intermediate stage in the progress of the disease, when the acute symptoms have subsided and the paralysis is the only remaining evidence, the paralysis has certain features which distinguish it—it is purely motor in type and flaccid in character, is often incomplete in degree, may be erratic in distribution, atrophy is an early accompaniment, the associated reflexes are diminished or lost, and the reaction of degeneration appears early.

The real difficulties in diagnosis occur in relation to certain unusual combinations of circumstances, the most important of these being —

- 1 When the clinical course has been of the mild semi abortive type, and the sustaining of an injury has coincided with the appearance of a paralysis
- 2 When the surgeon sees the case so long after the onset of the illness that there is no opportunity of obtaining a proper history, and a traumatic paralysis is confused with one resulting from poliomyelitis, e.g. an obstetrical paralysis of the upper extremity may be mistaken for an infantile paralysis
- 3 When a cerebral or upper neurone lesion precedes or accompanies the spinal disease, and a spastic paralysis exists alongside the flaccid one

In mild cases of the disease where one or two muscles only have been affected the true state of affairs may be entirely overlooked until some error in gait becomes apparent.

Amyotonia congenita has been confused with infantile paralysis,

temporary loss of a deep reflex. The great bulk of the cases belong to the spinal type, and, because the lumbar enlargement is the common site, the paralysis usually affects one or both of the lower limbs.

It is difficult to exaggerate the importance of the early tenderness, because it is so distinctive of this form of paralysis. It is the result of irritation and congestion of the posterior root ganglia, and according to the extent of the central infection it is either localized to the affected area or is general in its distribution; it lasts for about six weeks, and is definitely exaggerated by massage or exercises.

CLINICAL STAGES IN THE PROGRESS OF THE DISEASE

It is usual to divide the clinical progress of the disease and its



FIG. 459.—Infantile Paralysis.

The left foot shows a talipes equino varus deformity, paralytic in origin. The extensor and peroneal groups are paralysed.

sequelæ into stages, an arrangement which has much to recommend it, because it associates pathology with clinical evidence and with treatment. This division is as follows:—

1. The stage of onset.
2. The stage of convalescence.
3. The chronic stage.

The Stage of Onset. This embraces a period extending from the commencement of the disease to about the end of the sixth week. Clinically it is a phase characterized by hyperæsthesia, tenderness, and

in any form, and to keep the affected limb at rest. Sound physiological teaching governs these ideals, a peripheral stimulus is apt to be reflected in a congestion of the related portion of the central nervous system, and if an inflammatory condition already exists, peripheral irritation is particularly harmful. There is the further subjective reason that the paralysed limb is a painful one, and any indiscreet movement or massage increases the suffering.

The rules which govern the treatment of the early stage may be summarized as follows: *secure rest of the part, avoid irritation, and prevent deformity.*

It is not difficult to put these principles into practice, though constant care must be exercised to ensure that the ideals are being fulfilled.

However slight the general evidences may be, the child must be confined to bed and kept as warm as possible. If much pain is complained of, it is kept in check by bromide and chloral. A light splint, heavily padded with cotton wool, is provided for the affected portion, the splint being so designed that the affected muscles are maintained in a relaxed position, deformity is thus prevented, and the natural recovery of the weakened muscles is hastened. A light mould of plaster of Paris modelled to the part and lined with cotton-wool makes an excellent splint. If there is much general tenderness, great relief may be obtained by suspending the child on a sheet in a bath of warm water, and if arrangements are made to maintain the water at a comfortable temperature, the child may be kept therein for hours or even days.

Fixation of the part is continued as long as tenderness persists. The splint should be removed once a day to permit rearrangement of the padding, and at this time the skin may be gently bathed with methylated spirit.

The practice has been generally adopted of administering urotropin in these cases, the drug is said to delay or even to prevent infection through the antiseptic action of its formaldehyde basis. If any benefit is to follow its use it must be given in the earliest stages of the disease, its preventive action being exercised by administering it to cases who have been in contact with infection. Experimentally the value of the drug appears to have been proved, though there is a difference of opinion regarding its value.

When possible, cases should be given the benefit of serum treatment. The value of Flexner's serum has been established, but to be of benefit it must be administered in the earliest stages of the disease. In the ordinary spinal type, it is administered intrathecally, and as far as possible in proximity to the region of the spine in which the disease exists. Cases which show signs of cerebral paralysis may have the injection made through a small trephine opening.

DURING THE PERIOD OF CONVALESCENCE With the complete

but the history of the case and the nature of the paralysis ought to be sufficient to distinguish the one from the other.

PROGNOSIS

Problems of prognosis are occasionally presented to the surgeon, and it is therefore well that he should have some estimate of the possibilities. Early cases have a serious aspect under the following conditions:—

- (a) In young children.
- (b) In large epidemics, and particularly at the commencement of the epidemic.
- (c) When the paralysis affects the upper extremities.



FIG. 460.—Talipes calcaneus.

An example of paralytic talipes calcaneus in boy 8 years old.

- (d) When the paralysis is of the slowly extending type.
- (e) When the paralysis is extensive.
- (f) When much tenderness accompanies the paralysis.

Questions are likely to be put regarding the prospects of spontaneous recovery, and the answer given should be a guarded one. The surgeon should never commit himself in this respect at the outset of the disease; he should rather be content with the general statements that a strong tendency to natural recovery always exists, that early recognition of the disease and efficient treatment favour this tendency, that the ultimate extent of the disease will probably be a good deal less than that at first indicated, and that the spontaneous recovery proceeds actively for a period of about six months, and is still evident, though to a greatly lessened degree, at the end of two years.

TREATMENT

We have indicated the practical value of dividing the clinical course of the disease into stages, and the importance of the subdivision is apparent when questions of treatment arise, because the methods vary according to the stage of the disease.

DURING THE ACUTE OR INTRODUCTORY PERIOD. The ideals to be kept in view during this period are to avoid peripheral irritation

are explained by demonstration and practised under the supervision of one who is specially trained in this branch of the work. It is particularly important to avoid strain or fatigue in connection with the performance of the exercises.

While the active treatment is proceeding care must be taken to prevent deformity occurring, healthy muscles undergoing a progressive contraction, weakened muscles becoming lengthened—changes which are detrimental to their respective tissues—therefore splints are applied in the intervals between active treatment. For the sake of lightness, celluloid or aluminum is used, and the design of the splint is so arranged that deformity is corrected or prevented.

The question will naturally arise as to when the child is to be allowed to go about. Where the upper extremity is concerned this may be permitted as soon as acute symptoms have subsided, provided that the affected arm is suitably adjusted in its splint. In paralysis of the back and abdominal muscles, prolonged recumbency is dangerous, because of the risk of pneumonia, therefore as soon as tenderness has subsided a back support with belt is provided, and the child is allowed to sit up.

In affections of the lower extremity, if we consider the results which Lovett obtained in some 1,800 cases, we see that



FIG. 461.—Infantile Paralysis

A neglected example of a paralytic talipes equinus of the left foot. The falling of the anterior tarsus gives the foot an appearance of a cavus deformity.

to permit walking before the first year is completed is to incur an undue amount of risk. Our practice therefore has been to forbid walking until one year has elapsed, if at the end of that time, recovery is apparently complete, walking without appliances is permitted, if any weakness still exists, an appliance is provided which while it makes walking possible, yet prevents malposition and deformity.

Types of Ambulatory Appliances In the case of the upper extremity, an abduction splint of the aeroplane or platform type is the most suitable. It secures the right-angled abducted position of the shoulder joint, while adjustments can be fitted which control the forearm, wrist, and hand in the desired position.

Paralysis involving the muscles of the spine or abdominal wall demands the application of a posterior supporting jacket or brace, if the abdominal muscles alone are paralysed, a well fitting corset is sufficient.

Paralysis of the lower limbs may present a difficult problem. The

disappearance of pain, both subjective and objective, the treatment passes into a more active phase.

The nutrition of the affected muscle is improved by gentle massage of the part, and by the application of radiant heat, two measures which induce improvement in the tissues by increasing their vascularity. These measures are practised twice a day, the duration being limited by the appearance of fatigue.

Electrical applications are often advocated at this stage, but it is doubtful whether their use produces any real improvement. Faradism is alarming and painful to a young child, and, though the latter objection can be largely eliminated by the use of the Smart-Bristow coil, the forcible contraction of the muscle which faradism produces may well have harmful results unless the technique is carefully controlled by an expert observer. Galvanism is a more acceptable method, for it tends to improve the local nutrition. The sinusoidal and the Morton wave current are also preferable to faradism. The high frequency method is not to be recommended.

After a few weeks of massage and heat therapy, a beginning is made with what is probably the most important of all the remedial measures—muscle training—the re-education of the nerve cells to supply power to the weakened muscles. In discussing the pathology we alluded to the focal distribution of the disease; it is this which makes muscle training possible, because in the average case it is unlikely that there is a destruction *en masse*—adjacent cells are probably undamaged, and it is soon possible for the healthy tissue to open up fresh pathways of communication with the efferent fibres, and to develop a new pathway around the damaged nerve centres so that function is restored to the paralysed muscle. A further great advantage which muscle training secures is the improvement in the contraction and development of the muscle, for nothing improves tone and condition like voluntary contraction.

In itself the scheme of muscle training is a simple one. If the muscle is completely powerless, the patient concentrates his attention on an attempt to accomplish the movement while it is being performed passively by the surgeon; if a certain amount of power is retained the patient contracts the muscle as far as is possible, and thereafter the full arc of movement is completed by the surgeon. When the muscle is capable of performing the full voluntary range of movement, increasing resistance is gradually added.

Yet, simple though this may seem, the most careful supervision is required if harm is to be avoided. The danger is that of encouraging erroneous muscular balance, of permitting healthy muscles to assume the work which ought to be carried out by the weakened members.

In a work of this description it is impossible to give any real detail regarding this most important subject; special works must be consulted, but the essential points are that after the exact location of the paralysis has been carefully worked out, the proper remedial exercises

in structural changes in the related bones, the forces of Wolff's law come into play, and the related osseous structures may eventually undergo considerable remodelling.

It is apparent that the methods used in the correction of deformity will depend upon the situation of the error, and the stage at which it has arrived. Speaking in general terms, the sequence of attempts at correction will be —

- 1 Weight
- 2 Gradual manipulative extension
- 3 Rapid correction under anæsthesia
- 4 Operative measures (fasciotomy, tenotomy, myotomy, and osteotomy)

Deformities considered Locally

Lower Extremity

Hip Flexion and dislocation are the deformities which result from paralysis of the muscles around the hip joint.

Flexion is a sequel to paralysis of the hamstrings and of the gluteal

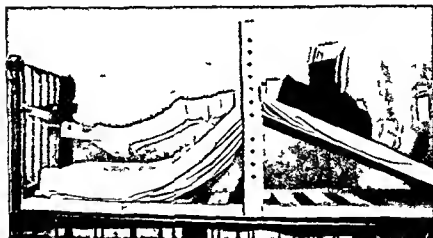


FIG. 463 —The Schwartz Frame in use in the correction of severe Hip Flexion Deformity following Infantile Paralysis

muscles, the flexors being unopposed. The deformity is corrected by applying double extension, the child being fixed upon a Whitman frame which is angled opposite the hip joints. A double Thomas's hip splint may be used for the same purpose.

Cases which fail to respond to these methods may require fasciotomy or a separation of the soft parts from the anterior superior spine and crest of the ileum for a distance of about $1\frac{1}{2}$ inches on both inner and outer surfaces (Soutter's operation). The projecting anterior spine is thereafter removed with bone forceps and the child is fastened on a correction frame.

use of crutches should be encouraged, as the local mechanical demands are thereby simplified. A well-fitting calliper splint is perhaps the most efficient appliance; if fitted with a pelvic band and a thigh cage, it controls and corrects weakness of the hip muscles, it is excellent for paralysis around the knee, and, if fitted with a stop, it can easily be adapted to paralysis affecting the ankle joint.

If the paralysis is localized to the limb below the knee, various types of appliance are used, according to the deformity which exists. In both equinus and calcaneus deformities a short calliper brace is excellent, stops being inserted to afford the necessary correction.

Lovett's internal boot brace is a good appliance for simple drop foot. Lateral deformities, varus or valgus, require a lateral iron with a heel

pin, or a clubfoot shoe may be used.

The question is often asked—if the child is not allowed to walk, are other forms of exercise permissible? The answer is that swimming may be allowed if the paralysis is not too extensive, and the same applies to tri-cycle riding.

These various details of treatment are persevered in until it is apparent that the maximum degree of improvement has been attained. In point of view of time, this will probably mean a

period of about two years. Thereafter the treatment will consist in the use of mechanical appliances to aid the weakened part, or of operative measures designed to improve function or to increase stability.

The Correction of Deformity. The development of a deformity in a paralysed limb must be accepted as evidence of imperfect treatment, for, if the case is observed early and thereafter is carefully treated, no deformity should result. Gravity and the pull of unopposed muscles are the forces responsible for the error. The muscular paralysis results in a postural deformity which is controlled by the influence of gravity, and the direction of the unopposed pull of the healthy muscles. After some time, if the deformity remains uncorrected, adaptive changes appear in the soft parts and particularly in the fascial and fibrous structures; ligaments are shortened, tendons contracted, and fascial bands thickened and fore-shortened, the changes being apparent on the flexion side of the deformity. Further persistence of the error results



FIG. 462.—Infantile Paralysis (paralytic talipes equino cavus).

Front and back views of boy affected with infantile paralysis of right foot. The deformity is chiefly one of equinus, but there is a certain amount of cavus and a slight degree of varus.

in structural changes in the related bones, the forces of Wolff's law come into play, and the related osseous structures may eventually undergo considerable re modelling

It is apparent that the methods used in the correction of deformity will depend upon the situation of the error, and the stage at which it has arrived. Speaking in general terms, the sequence of attempts at correction will be —

- 1 Weight
- 2 Gradual manipulative extension
- 3 Rapid correction under anæsthesia
- 4 Operative measures (fasciotomy, tenotomy, myotomy, and osteotomy)

Deformities considered Locally

Lower Extremity

Hip Flexion and dislocation are the deformities which result from paralysis of the muscles around the hip joint

Flexion is a sequel to paralysis of the hamstrings and of the gluteal



FIG 463 —The Schwartz Frame in use in the correction of severe Hip Flexion Deformity following Infantile Paralysis

muscles, the flexors being unopposed. The deformity is corrected by applying double extension, the child being fixed upon a Whitman frame which is angled opposite the hip joints. A double Thomas's hip splint may be used for the same purpose.

Cases which fail to respond to these methods may require fasciotomy or a separation of the soft parts from the anterior superior spine and crest of the ileum for a distance of about $1\frac{1}{2}$ inches on both inner and outer surfaces (Soutter's operation). The projecting anterior spine is thereafter removed with bone forceps, and the child is fastened on a correction frame.

Dislocation. If hip flexion is allowed to persist in the presence of paralysed gluteal muscles, subluxation of the femoral head is apt to occur, and this may easily pass into a complete dislocation, especially if injudicious attempts at correction of the flexion are made. The deformity is treated by first correcting the flexion and thereafter performing the strap and buckle operation which Sir Robert Jones has described.

Knee. Deformities of the knee are particularly common; flexion is the most frequent, a neglected case passing into the combined errors of flexion with a posterior subluxation of the tibia, paralysis of the extensors being the causative factor.

Hyperextension, the result of hamstring paralysis, or of weakening of the gastrocnemius, is common. Knock-knee is a frequent accompaniment of paralysis around the knee, and particularly when there is unopposed action of the biceps.

Flexion, if not too rigid and extreme, is corrected by gradual

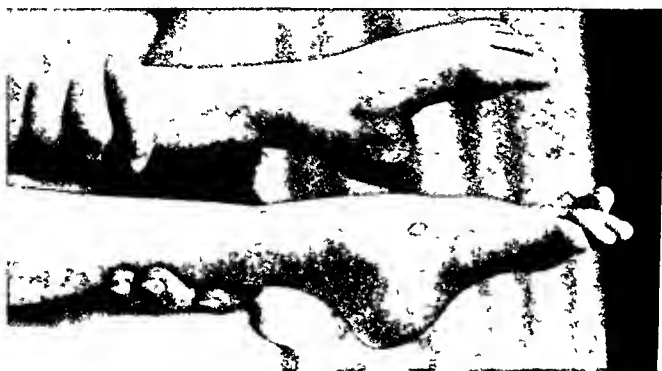


FIG. 464.—Double Paralytic talipes (Girl 7 years old).

There is a paralytic talipes equinus of the right foot, while the left foot is in a calcaneus position with drooping of the anterior tarsus

extension, the limb being fastened in a Thomas's knee splint. Too rapid correction must be guarded against in view of the risks of inducing a posterior subluxation. It may be necessary to combine a fasciotomy or a tenotomy with the manipulative method.

Resistant cases are often amenable to the method of plastic correction; a plaster casing is applied from the groin to the toes and a transverse cut is made through the posterior two-thirds of the plaster at the level of the knee joint. The slit is opened by the insertion of a succession of wedges of increasing size, and it is amazing how quickly and easily a bad deformity is corrected.

Hyperextension is treated by the application of a calliper splint combined with corrective bands; severe cases may require a lengthening of the quadriceps-extensor tendon.

Knock-knee is improved by lateral traction combined with a calliper splint, or an osteotomy may require to be done.

Posterior subluxation of the tibia on the femur, so often combined with a flexion deformity at the knee, is improved as the flexion is corrected. Intractable and extreme cases may be corrected by forward elevation of the tibia by means of the genuelast.

Ankle. The various deformities at the ankle joint—equinus,

calcaneus, *varus*, *valgus* and *cavus*—are corrected by such simple manœuvres as stretching, manipulation, fasciotomy, and tendon lengthening. The method of the cut plaster case and wedges, as described in connection with the knee, is often efficient.

Complete division of a shortened tendon as a corrective measure is to be avoided, it may be followed by irreparable weakness of the foot, and a flail gait. For example, a patient with an equinus deformity of the foot combined with a weakness of the thigh extensors is rendered peculiarly helpless if the tendo Achilles is divided. Several details of



FIG. 465.—Old standing Infantile Paralysis of left Arm and particularly of Forearm and Hand.

the correction of foot and ankle deformities are discussed in connection with the operative treatment.

Upper Extremity

Shoulder The deltoid is the most common site of shoulder paralysis and, because the pectorals and the latissimus dorsi usually retain their power, the resulting deformity is one of adduction and internal rotation. If in addition to weakness of the deltoid, there is paralysis of the biceps and triceps, there is a tendency for the joint to undergo a subluxation. Both adduction and subluxation deformities are easily preventable if care is taken to keep the upper

arm abducted at a right angle on a platform splint. A combined deformity of adduction and subluxation requires stretching and manipulation to bring the arm into right-angled abduction, and division of the pectoral and latissimus dorsi tendons may be necessary.

Internal rotation is the result of unopposed action of the subscapularis muscle, and, if the deformity is extreme, division of the tendon may be required.

Subluxation of the shoulder joint is a difficult problem; plication of the capsular ligament and fascial sewing (Gallie) are the measures which have met with the greatest degree of success.

The Elbow, Forearm, and Hand. The deformities to which these parts are liable present no unusual feature. The influence of gravity and muscular pull produces the errors, and in any given case the displacement can be foreseen and prevented. Deformities which have already been acquired are corrected by stretching and manipulation.

The Spinal Column. The paralysis of muscles directly or indirectly related to the spinal column is apt to be associated with the development of a lateral spinal curvature (scoliosis). The influence of the ordinary



FIG. 466.—Infantile Paralysis affecting the posterior Spinal Muscles.

As the child is unable to support himself in the erect position, he stands and walks in the attitude shown.

long spinal muscles in this respect is obvious, but there are other muscular groups which, though more remote, have yet considerable influence, e.g. the shoulder and the abdominal muscles. The judicious use of a spinal support prevents the development of the deformity; the acquired case is treated by the methods described in connection with scoliosis—recumbency, manipulation, and corrective jackets.

OPERATIVE TREATMENT

In a certain proportion of cases, there comes a time when it is obvious that conservative treatment can offer no further prospect of improvement in these the surgeon has to consider whether operative measures are now justifiable

If the conditions are such that operation can (1) improve function, or (2) increase the stability of a flail joint, the measure is justified. The different procedures which have been designed, with one or other of these aims in view, are numerous, and only a summary of them can be given here. It is convenient to consider the methods according to the ideals which they have in view



FIG 467 —Infantile Paralysis affecting the long Spinal Muscles
The child being unable to assume the erect position walks on all fours

Operations designed to improve Function

The following procedures have been practised —

- (1) Tendon transplantation
- (2) Muscle transplantation
- (3) Nerve transplantation
- (4) Neurotization of Muscles

(1) **Tendon Transplantation** This is the most effective function-improving operation which we have at our disposal, for by it we are able to substitute healthy tendons for those which are paralysed. If the operation is to afford the maximum of success certain conditions must be fulfilled —

- (a) The transplanted tendon must be of sufficient strength to assume its new function

- (b) Any pre-existing deformity must be corrected before the transplantation is carried out.
- (c) The direction of the transplanted tendon should be a straight line from origin to new insertion.
- (d) The tendon should be carried in the subcutaneous fat or in the sheath of the paralysed tendon, if such is possible.
- (e) The new attachment should be by implantation into the bone or by a perforation and loop attachment.
- (f) Linen thread or fine silk should be employed to suture the tendon in position.
- (g) The tendon should be attached in a condition of moderate tension.
- (h) As far as possible the function of the transplanted tendon should be similar to that which it previously exercised.
- (i) The operation should not be performed on children below the age of five years.



FIG. 468.—Infantile Paralysis affecting the Deltoid.

Two photographs illustrating the result of transplantation of the trapezius muscle into the humerus. The power of abduction and elevation of the arm is remarkably good.

The after-treatment is a matter of great importance, for upon it the ultimate success of the operation largely depends. After operation, the part is placed in such a position that no undue strain is exerted upon the tendon. The limb is kept in complete fixation for six weeks, preferably in plaster—if not, in some type of reliable fixation apparatus; thereafter massage is instituted, and remedial exercises, designed to develop the function of the transplanted tendon, are begun. A cast of the part in the corrected position has previously been taken, and upon this a light celluloid splint is made. This the patient wears constantly for a period of six months, it being removed for the exercises and for purposes of washing.

(2) Muscle Transplantation. The principles which apply in

this operation are very similar to those of tendon transplantation. The conditions suitable for the operation are less common, the transplantation of the trapezius into the humerus to secure abduction of the arm and the transplantation of the tensor fasciae femoris into the femur to reinforce a weak gluteus medius are types of this operation.

(3) **Nerve Transplantation** This operation, by which a healthy nerve is attached to one whose function has disappeared, is not widely practised. The procedure cannot at present be recommended as a routine measure.

(4) **Neurotization of Muscles** The work of Steindler and others has raised the possibility of restoring function to paralysed muscles by implantation of the peripheral end of a healthy nerve. Experimentally the method has been a success, but no clinical results are yet available.

Operations designed to Increase the Stability of a Flail Joint

If there is a prospect of improving the function of a paralysed limb by increasing the stability of a flail joint, a variety of operative procedures are at the disposal of the surgeon. The various methods may be considered separately.

1 **Arthrodesis** The removal of the opposing cartilaginous surfaces of a diarthrodial joint will result in a fixation of the opposing surfaces by either fibrous or osseous ankylosis. The procedure is made wide use of in the fixation of flail joints.

The method has certain disadvantages, and these may be stated first. The procedure is an irrevocable one, for, short of a subsequent arthroplasty being done, the joint remains permanently stiff. Some degree of shortening results from the operation, and for this reason it should not be practised in children below the age of six years, and when the operation is being carried out, only the minimum of substance necessary to secure the desired result is removed. Under certain conditions, particularly of position attempts to secure ankylosis fail. Yet, in spite of these disadvantages, the operation has a certain field of usefulness.

In the hip joint the operation is disappointing because of the



FIG 469 —A Paralytic Talipes calcaneus of the left Foot (Boy 4 years)

difficulty in guaranteeing complete ankylosis, and moreover a flail hip can be very efficiently controlled by an ischial bearing brace.

Arthrodesis of the knee is an operation which one tries to avoid in children : it invariably interferes with the growth of the limb, and in any event a flail knee is easily controlled by the use of a brace.



FIG. 470.—Talipes calcaneus.

The result of operation for marked talipes calcaneus. The operation was performed according to Whitman's method.

It is in the ankle joint that the operation is most widely practised—not for the simple deformity of a paralytic dropfoot (which less drastic measures improve), but for the troublesome calcaneo-cavus type of deformity. It is in this class of case that the arthrodesis and tarsal exsection types of operation associated with Jones and Naughton-Dunn's names are performed.

In a simple arthrodesis of the ankle joint, if the exsection is limited to the tibio-fibulo-astragaloid joint, there is a tendency for the foot anterior to the mid-tarsal joint to drop ; therefore, if the best result is to be secured, both ankle joint and mid-tarsal joints should be ankylosed.

In cases of completely flail ankle-joint, and in severe examples of calcaneo cavus, the operation of astragalectomy is sometimes per-

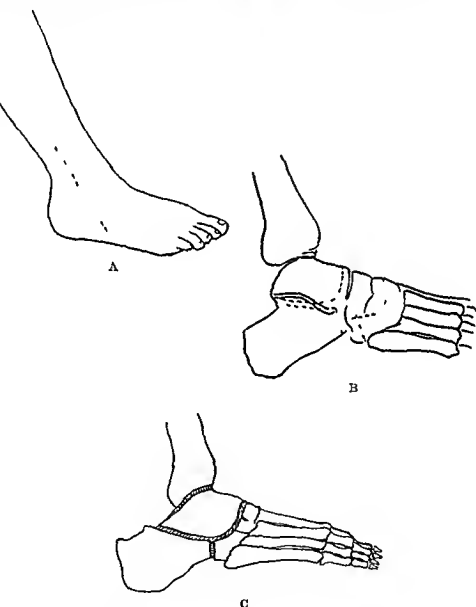


FIG 471 —Dunn's Operation for stabilising the Ankle Joint

A Line of Incision. B Outline of the tarsal exsection C The readapted foot
(After Naughton Dunn)

formed. The operation is not advisable in young children, as subsequent growth may result in considerable distortion of the foot. Arthrodesis operations are rarely advisable in the upper extremity

difficulty in guaranteeing complete ankylosis, and moreover a flail hip can be very efficiently controlled by an ischial bearing brace.

Arthrodesis of the knee is an operation which one tries to avoid in children : it invariably interferes with the growth of the limb, and in any event a flail knee is easily controlled by the use of a brace.

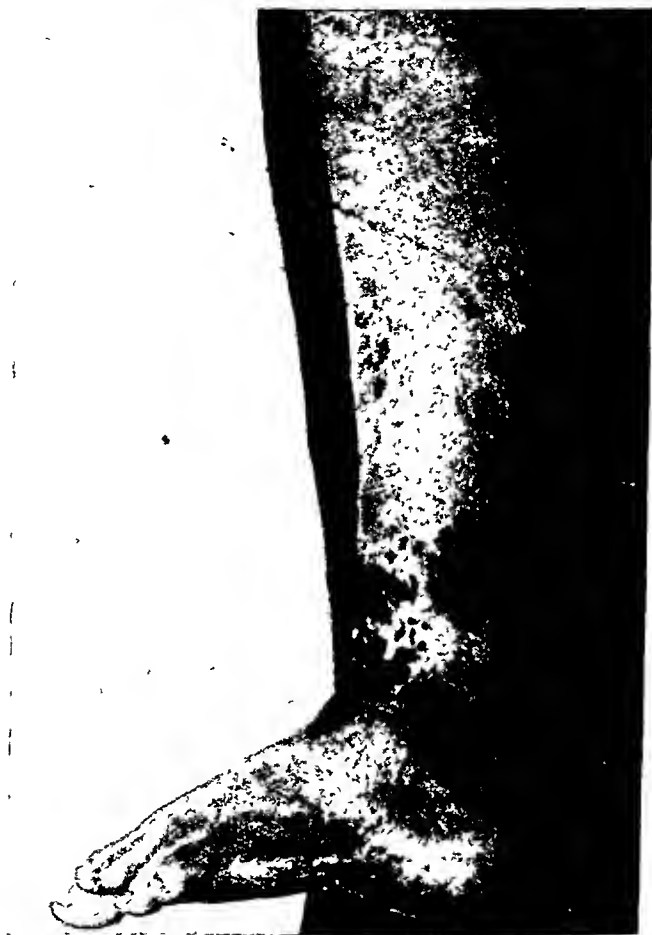


FIG. 470.—Talipes calcaneus.

The result of operation for marked talipes calcaneus. The operation was performed according to Whitman's method.

It is in the ankle joint that the operation is most widely practised—not for the simple deformity of a paralytic dropfoot (which less drastic measures improve), but for the troublesome calcaneo-cavus type of deformity. It is in this class of case that the arthrodesis and tarsal exsection types of operation associated with Jones and Naughton-Dunn's names are performed.

In a simple arthrodesis of the ankle joint, if the exsection is limited to the tibio-fibulo-astragaloid joint, there is a tendency for the foot anterior to the mid-tarsal joint to drop ; therefore, if the best result is to be secured, both ankle joint and mid-tarsal joints should be ankylosed.

in plaster for six weeks subsequent to the operation, and thereafter a light 'pexuloid' splint is worn for one year. In cases of eversion deformity at the hip joint, the silk is carried from the outer surface of the great trochanter to be inserted into the anterior inferior spine of the ilium, the silk being pulled sufficiently taut to correct the eversion.

A certain amount of criticism of the method has centred round the possibility of the silk producing such a degree of irritation that the suture has to be removed. Since we have used the method of gelatinous preparation there has been no trouble of this nature.

3 Tendodesis or Tendon Fixation This method was first practised by Tilanus (1898), and a great deal of work in relation to it has been done by Gallic. It is practised in relation to paralytic deformities of the ankle joint. It consists in converting one or more of the paralysed tendons into ligaments. The desired tendons are exposed, they are drawn taut so as to correct the deformity which exists, and are afterwards fastened in the taut position by securing them to the appropriate bone—usually the anterior surface of the tibia immediately above the articular edge. The tendon is secured in place by sutures of kangaroo tendon or silk, which pass through the underlying bone, periosteum, or cartilage. After the skin wound is closed, the foot is encased in plaster in the corrected position for six weeks, after which walking is allowed.

4 Fine Fascial Transplants Strips of fascia lata twisted into cords may be used in the ankle joint and in the joints of the upper extremity to correct a flail deformity. The transplants are inserted into holes in the related bony surfaces.

Bone transplants have been employed in a somewhat similar way. The grafts are usually cut from the outer surface of the femur and great trochanter. They are appropriately shaped, and inserted and attached so as to correct the deformity. In ankle-joint deformities two transplants are usually employed, one on the outer side extending from the posterior surface of the tibia behind the median malleolus to be attached to the tubercle of the scaphoid, the other on the anterior surface extending from the front of the fibula to the upper surface of the cuboid bone.

II SPASTIC PARALYSIS

Any influence which exerts a destructive effect upon a point in the tract of the upper neurone from its cortical cell to its termination is a factor in the production of spastic paralysis. Impairment of upper neurone tissue destroys its functions of providing the voluntary influences which control and restrain the excitability of the spinal reflexes and, in the muscles which are thus affected, there is an exaggeration of reflexes, a hypertonicity and a spastic contraction which justifies

The method is occasionally practised in the shoulder-joint in older children.

2. Silk Fixation. Lange suggested in 1907 that certain paralytic deformities, such as dropfoot, might be improved by the insertion of silk strands from one bone to another so as to hold the weakened joint

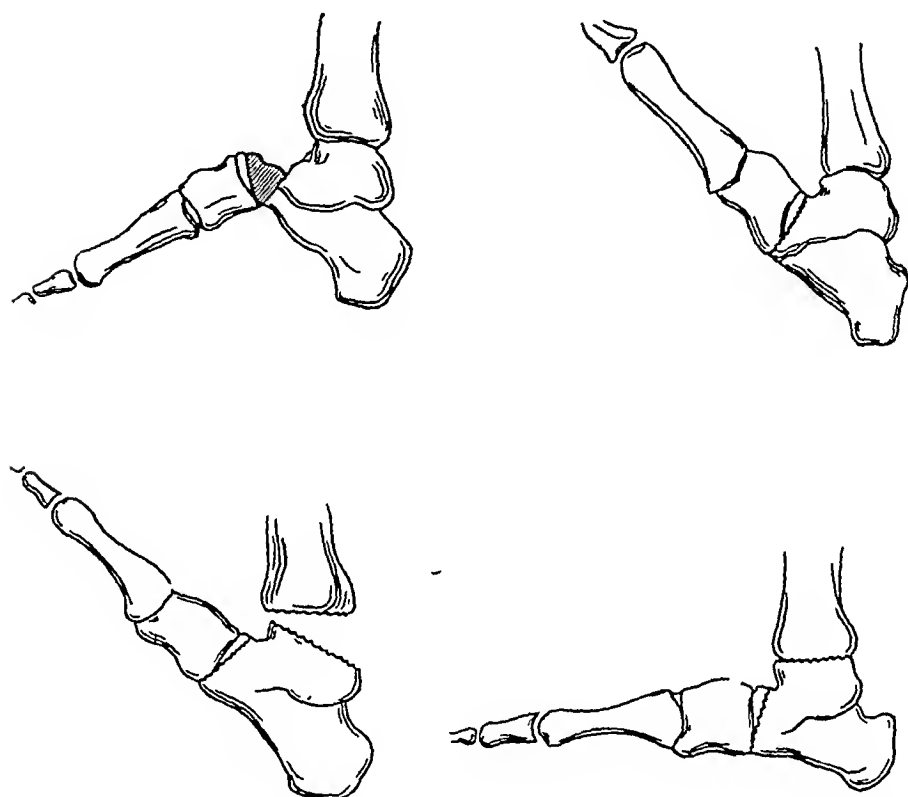


FIG. 472.—Jones's Operation for correction of a Talipes calcaneus.
(Robert Jones.)

in the corrected position. We have practised this type of operation in two classes of case with very encouraging results :—

- (a) In paralytic dropfoot.
- (b) In paralysis of the gluteal muscles when the eversion of the limb interferes with walking.

The silk is prepared according to Lange's technique, being boiled in 1 in 1,000 corrosive sublimate for one hour, but after drying it is again boiled in a solution of gelatine for thirty minutes. Afterwards it is stretched and dried and stored in a jar containing formalin vapour.

In a suitable case of dropfoot the silk is carried from the base of the fifth metatarsal along the sheath of the peroneus tertius tendon and secured to the shaft of the tibia at a suitable level. The foot is encased

as the cerebral cases are concerned, the etiological grouping which Sachs suggested is sufficiently embracing



FIG 474 —Spastic Paralysis

The characteristic appearance of a spastic affection of the left wrist and hand. The wrist is flexed, the thumb adducted, the fingers are extended at the metacarpophalangeal joint and flexed at the interphalangeal joints.

A Causes which have operated during the Intra uterine Period

Congenital cerebral defects—true Porencephaly

Hæmorrhages of intra uterine origin

Agenesis corticalis

B Causes which have been acquired at or after Birth

Meningeal hæmorrhage

Intra cerebral hæmorrhage

Embolism

Thrombosis—the result of congenital syphilis or marasmus

Conditions which have resulted from any of the foregoing vascular lesions, such as cysts, softening

Atrophy and sclerosis

Chronic meningitis

Primary encephalitis

Many observers have recorded the occurrence of spastic paralysis in association with premature birth, and the influence of this factor appears to be in relation to the development of the pyramidal tract. It is believed that the crossed pyramidal tract at the seventh month of foetal life has not extended beyond the medulla. At the eighth month the projection of the tract has extended down the spinal cord as far as the dorsal region. In premature children, medullation of the pyramidal tract may be delayed and delay is likely to be associated with an arrest in the projection of the fibres. It is apparent, therefore, that we must recognize a wide divergence in the causes and degrees of the affection.

CLINICAL FEATURES

Onset with convulsions is common, and, since a large proportion of the cerebral palsies of early life are due to lesions affecting the cortex, such an onset is to be expected.

the description of spastic paralysis. In the proper sense of the term, there may be no true paralysis, but the physical ataxy which is present incapacitates the limb for ordinary functional purposes, and as a matter of fact, in many cases, a loss of power exists in addition to the spasticity.

The physiology of the disease, if one may use the term, is very similar to that of the hemiplegia of adults, but modified by the early period of life at which the condition has become manifest.

DISTRIBUTION OF THE DISEASE.

The incidence of the disease and its effects are variable. A paralysis affecting one side of the body is described as a *hemiplegia*; when the affection is limited to the lower extremities it is a *paraplegia*; if both upper and lower extremities are involved, the case is one of *diplegia*; an affection limited to a single extremity is a *monoplegia*.

According to surgical records the hemiplegic distribution is the most frequent: statistics indicate that about 75 per cent. of cases come under this heading. The diplegic form comes next in order of frequency; paraplegic forms are uncommon, and the monoplegic varieties are rare.

In a special type of the disease—that in which spastic paralysis is associated with poliomyelitis—the distribution of the paralysis is peculiarly erratic, individual muscles or muscle groups being



FIG. 473.—Spastic Paralysis.

A spastic monoplegia affecting the left arm and hand. There is slight involvement of the left face. The lesions are the result of a birth hæmorrhage

affected, flaccid muscles existing side by side with those of the spastic type.

ETIOLOGY AND PATHOLOGY

It is apparent that the pathology must be associated with the etiological influences, and reference is made to this relationship when questions of etiology are discussed. The essential feature is a destructive lesion of the upper motor neurone.

In the majority of cases, the site of the lesion is in the cerebrum. Cases are occasionally seen in which the lesion appears to be confined to the spinal cord—examples of degeneration of the distal portions of the pyramidal tract, the result of imperfect development. As far

knees are flexed, the feet are usually in an attitude of equino varus, but if the child has walked for any length of time with an uncorrected flexion and adduction hip deformity, the feet may acquire an accommodation distortion towards valgus or even calcaneo valgus, the result of the transference of body weight to a more forward position, the os calcis being fixed by the gastrocnemius. The upper extremity, when spastic, is flexed at the elbow, the forearm is pronated, the wrist flexed, the thumb adducted and contracted into the palm, and the fingers flexed. If a particular movement of one part of the limb is attempted, it is characteristic of the condition that all the muscles of that extremity pass into a spastic contracted state.

In a case of any severity, the tendon reflexes are exaggerated—a clonus reaction may be elicited and the Babinski and Oppenheim's signs are present.

A certain proportion of cases show athetoid movements of the affected extremities—purposeless irregular, arrhythmical movements. This symptom is one of consequence from the point of view of prognosis.

Mental Symptoms

Some degree of mental disorder is apparent in the majority of cases. The derangement varies from complete idiocy to a degree of instability which is only apparent at times of unusual stress. It may be said that two factors control the degree of mental derangement (1) the extent of the lesion, and (2) the nature of the lesion.

So far as the former of these is concerned, widespread bilateral lesions are the most unfavourable, hence the frequency with which severe mental disturbance is associated with a diplegic paralysis. In connection with the type of lesion congenital causes, and particularly proencephaly, are the most serious. A paralysis resulting from



FIG 477.—Spastic Hemiplegia affecting left Face Arm and Leg



FIG. 175.—Spastic Talipes equinus of the right Foot.

There is also some degree of cavus deformity.

It is when the child begins to walk or when an attempt is made to use the limbs in some 'intention' movement that the characteristic features of the disorder become most apparent. The date at which these various 'intention' movements are attempted is later than normal. Walking, for example, is delayed considerably beyond the date at which it should begin, and, when the movement is carried out it is performed in a characteristic ataxic inco-ordinated fashion. The movement reminds one of the stiff marionette-like performance of a mechanical figure.

As age advances, the affected limb or limbs undergo characteristic deformities, determined by the relative strength of the opposing groups of muscles. The hips are flexed, adducted, and rotated inwards, the

Motor Evidences.

Muscular rigidity is the cardinal symptom of the disease. If the influence responsible for the paralysis has been a pre-natal one, weakness may be evident soon after birth. The child has difficulty in sitting erect, and when held in the erect attitude, the lower limbs may be pressed against each other while the feet are extended. The affected limbs have a characteristic which is best expressed as 'stiffness.' The extended joints appear to resist an attempt at flexion, and, as pressure is continued, the flexion attitude is assumed gradually.



FIG. 476 —Spastic Paralysis.

An example of double spastic talipes equinus. The limbs are adducted and the knees slightly flexed. In the left foot the child walks on the under-surface of the great toe and the head of the first metatarsal bone.

may be difficult, but the treatment is similar in both types, though the prognosis in the spinal variety is less hopeful

PROGNOSIS

It is an undoubted fact that the duration of life is materially shortened in the majority of cases of spastic paralysis. Peterson estimated that the subjects of paraplegia or of diplegia usually die before the twentieth year, and that few who are hemiplegic reach the age of



FIG. 478.—Spastic diplegia (Little's disease) (Boy 9 years old)
The physical appearance and gait of a severe example of spastic diplegia

forty. While recognizing that Peterson's estimates apply to the severe types of the disease, the general fact remains that the average life span is shortened in almost every case.

The prospects of recovery are important from the surgeon's point of view. Even in the absence of treatment, the hemiplegic will be able to walk, and as care and judgment are exercised in the treatment, so will the results improve. The disease usually undergoes a considerable degree of spontaneous recovery.

encephalitis is almost invariably complicated by some degree of mental disturbance.

Trophic and Sensory Changes. As far as can be ascertained, sensory changes are absent except in the so-called 'mixed' cases in which a spinal lesion accompanies the cerebral change. The chief trophic disturbance is retardation in growth of the paralysed member. The paralysed limb grows, but at a slower rate than the healthy extremities, and the earlier the onset of the palsy the greater is the disproportion.

The growth of the entire organism may be interfered with, the injury to the brain appearing to stunt development and prevent the patient attaining his normal stature.

Special Signs. Epilepsy is a feature in many cases; it is most frequent in the hemiplegic type.

A defective development of articulate speech is often noticeable, and in children who have learned to talk aphasia may accompany the palsy.

Hemianopsia has been noted as a rare development by Freud, Henschen, and Starr. Physical defects or stigmata of degeneration may become apparent in long-standing cases. Such cranial deformities as asymmetry of face and skull, microcephalus, leptcephalus, and 'cranium prognaceum' have been described. Fisher has called attention to the flattening of the skull often observed on the side opposite the paralysis in infantile spastic hemiplegia.

DIAGNOSIS

In a fully established case it is unlikely that an error in diagnosis will be made; the spastic hypertonic condition of the muscles is not simulated by any other disease.

Cases of hydrocephalus and of cerebral tumour may develop spasticity of certain muscular groups, and, while the physiological pathology which produces the muscular change is similar to that which occurs in true cerebral palsies, the progress of the cases in other respects is sufficiently distinctive.

The paralysis which accompanies certain cases of Potts' disease is distinguished by the evidences of the spinal lesion.

Hereditary ataxia or Friedrich's disease is an ataxic paraplegia caused by sclerosis of the posterior and lateral columns of the spine, but the disease is a progressive one, beginning with weakness and inco-ordination of the legs, later associated with similar changes in the upper extremities, and ultimately with affections of speech. In Friedrich's disease there is no real hypertonicity of the muscle.

Infantile paralysis is distinguished by the flaccid condition of the affected muscles, but in the mixed cases, where a cerebral affection accompanies the spinal lesion, difficulty may arise.

Spastic spinal paralysis (Spiller's disease) results in a spastic paraplegia similar to that observed in the cerebral type, and the distinction

may be difficult, but the treatment is similar in both types, though the prognosis in the spinal variety is less hopeful

PROGNOSIS

It is an undoubted fact that the duration of life is materially shortened in the majority of cases of spastic paralysis. Peterson estimated that the subjects of paraplegia or of diplegia usually die before the twentieth year, and that few who are hemiplegic reach the age of



FIG 478 —Spastic diplegia (Little's disease) (Boy 9 years old)
The physical appearance and gait of a severe example of spastic diplegia

forty. While recognizing that Peterson's estimates apply to the severe types of the disease, the general fact remains that the average life span is shortened in almost every case.

The prospects of recovery are important from the surgeon's point of view. Even in the absence of treatment, the hemiplegic will be able to walk, and as care and judgment are exercised in the treatment, so will the results improve. The disease usually undergoes a considerable degree of spontaneous recovery.

In bilateral palsies the prognosis as regards walking must remain unfavourable, though recent advances in treatment promise improvement.

The degree of mental involvement influences the prognosis, for it is natural that the less the intelligent response from the individual, the less successful will treatment prove.

Epilepsy is an ominous feature, and its appearance inevitably increases the gravity of the prognosis.

TREATMENT

EARLY OPERATIVE TREATMENT

It is a reasonable proposition that, if the exciting cause is such an accessible condition as a meningeal birth hæmorrhage, an attempt



FIG. 479 —Spastic Paralysis.

Girl 10 years old, suffering from severe spastic diplegia (Little's disease). The deformities which the illustration shows proved to be most difficult to correct. Adaptive shortening of various structures had taken place in the affected joints.

should be made to remove the harmful influence before it has time to effect destruction. It is an argument on this basis which has led to the *cerebral decompression operation* as the first possible line of treatment in spastic paralysis. If a newly-born child after a difficult birth shows signs of persistent asphyxia and cyanosis, accompanied by fits, the likelihood is that a meningeal or cortical hæmorrhage has occurred, and if this is in any way extensive a spastic paralysis will almost certainly result. If, from the cranial condition and neurological signs, there is sufficient evidence to localize the site of the disorder it is justifiable to expose the affected area, to remove the clot and to arrest the bleeding. The literature contains accounts of many

operations of this character, and in the opinion of certain observers, the results have been encouraging. We have practised the method on several occasions, we have taken the opportunity of following up the life history of those cases which survived, but we have been disappointed, for in our experience, at least, the expedient has never succeeded in preventing spastic paralysis, but in some cases, at least, has quite evidently intensified and extended the resulting disorder.

CONSERVATIVE TREATMENT

If conservative treatment is to yield its best results, the clinician must keep constantly in view the physiological error which is responsible for the muscular condition. There is no paralysis in the true



FIG. 480.—Spastic Talipes equinus

sense of the term—rather there is an uncontrolled activity which is apparent in the hypertonicity of the muscle. Recent work, and particularly that of Hunter, has suggested that the function of tone may be limited to certain fibrils innervated by non medullated nerves supplied with specialized types of nerve endings, possibly sympathetic in origin and, though our knowledge on these points is not yet sufficiently confirmed to influence our plan of treatment, the fact remains that uncontrolled hypertonicity is the distinctive feature of spastic muscle. The practical bearing of this is most important in relation to treatment, for it is apparent that any measures which will irritate the muscle and increase its tone are necessarily harmful, therefore we are careful to avoid such stimulating measures as massage, electrical treatment, *intermittent* stretching of affected muscles, and improper exercises of any kind.

The principles which we follow in the conservative treatment of a characteristic case embrace the following points —

- (1) The prevention of deformity by the *continuous* stretching of the affected muscles
- (2) The education of healthy muscles to oppose the abnormal contraction of affected groups

- (3) The education of the patient in the exercise of intentional individual movements.
- (4) The encouragement of the practice of rhythmic movement and of balance.

(1) **The Prevention of Deformity.** As soon as a spastic condition of the muscles becomes apparent, arrangements should be made for a splint to be applied which will oppose the over-contraction of the affected muscles. A double benefit arises from this provision—the *constant* stretching diminishes the hypertonicity of the affected muscle, while the mechanical influence of the splint prevents the acquisition of deformity. If the spasticity is neither marked nor actively progressive, the splint need only be worn at night, but in more fully estab-



FIG. 481.—Spastic Paralysis. An example of the equino cavus deformity.

lished cases it should be worn continually except when it is removed for exercises.

(2) **The Education of Healthy Muscle.** The deformity and inco-ordinated ataxic movements of a case of spastic paralysis are partly the result of the disappearance of a proper muscular balance. Certain groups of muscles are in such a condition of hyperactivity that the influence of healthy balance is lost to all intents and purposes. It is therefore an important aim in treatment so to develop the minus group that they are able to compete on more favourable terms with their plus opponents. By judiciously planned exercises this aim is secured, and, as improvement develops, the function of the part is benefited.

(3) **Intentional Individual Movements.** It is one of the most characteristic features of a spastic limb that, when even a minor movement is attempted, the complete musculature of the part tends to pass into spasm. If sufficient educative care is exercised, and the child is old enough and intelligent enough to grasp the principle of the scheme, he can be taught to practise single movements which demand the function of a single muscle or muscle group. While the intentional movement is being made, the child is instructed to attempt inhibition of any associated action of other muscles. Treatment on this basis begins with the coarser movements such as flexion of the elbow or

abduction of the shoulder, and it is only when these grosser movements have been performed satisfactorily that the finer co-ordinated movements of the hands and fingers are permitted. If this scheme of treatment is assiduously and conscientiously carried out, good results will certainly follow.

(4) **The Education in Rhythm and in Balance** The child is encouraged to practise rhythmic movements of the affected part. If these are carried out to music, they become more of a pastime than a duty. In lower limb affections, dancing serves the same purpose, and its practice should be encouraged under careful supervision.

The maintenance of balance is one of the first necessities if a good result is to be obtained, and many patients experience great difficulty in this respect. Special gymnastic exercises are arranged, the child being instructed to walk with the head erect and not to look at the ground. The walking should be carried out slowly and deliberately with the legs apart and the toes turned out. The patient should be encouraged to learn to stand on one foot. In many cases the child is taught to walk between parallel bars or ropes, upon which he can place his hands, and thus maintain his balance. Walking chairs are also useful.

The practice of teaching a child to walk by pushing a chair in front of him is to be deprecated, because he acquires the habit of walking in a bent position, an attitude which further interferes with the maintenance of balance.

General Lines of Treatment Careful general treatment is demanded in every case. An open air life, abundance of healthy exercise, a sufficiency of nourishing food, and freedom from strain of any kind, physical or mental, are the chief necessities.

OPERATIVE TREATMENT

In many cases there is a considerable field for treatment by operation. It may be that conservative measures have failed to produce much result, or have already yielded the maximum of benefit or that a persistent deformity is interfering with further improvement, or that the reinforcement of the weaker muscular groups offers promising possibilities, or that there is a prospect of correcting by operative measures the central nervous error which is responsible for the spasticity. There is therefore a wide range of operative possibilities, and, for convenience of description, it has become usual to divide the operative measures into—

- A Operations on muscles and tendons
- B Operations on the nervous system comprising cerebrum, spinal cord, and peripheral nerves

While it is true that there is a wide scope for operative interference, we have to be careful to choose suitable types of cases. For example, the child should be over five years of age before operation is attempted,

unless it be a procedure intended to relieve an urgent deformity. Similarly, if there is much coincident mental disturbance, it is unwise to attempt an operation which demands much subsequent education. But, with these exceptions, the choice of operative interference is so wide that some degree of post-operative improvement may be looked for in the majority of cases.

A. Operation on Muscles and Tendons

Tenotomy, Tendon Lengthening and Myotomy.

These operations are generally designed to ensure correction of a deformity.

Haphazard division of a shortened tendon is to be condemned: it is particularly unfortunate if attempted at the ankle joint in dealing



FIG. 482.—Spastic Paralysis.

An example of neglected spastic diplegia in a girl 11 years old. The hip joints are flexed and adducted, the knees acutely bent, and the feet in an equinus attitude.

with a shortened tendo Achilles. Tendon lengthening by any of the recognized methods is the operation of choice in cases of spastic ankle-joint deformity.

Tenotomy may be practised in severe examples of knee flexion, the biceps being left entire. The operator will do well to remember, however, that, if knee flexion has been accompanied by an equinus ankle deformity, the relief of the contracted tendo Achilles may result in considerable improvement of the knee condition.

The operation of myotomy is practised for deformities in relation to the hip joint. Adduction deformity is relieved by division of the adductor group. Flexion deformity, often accompanied by internal rotation, is corrected by detachment of the muscular origin of the

gluteus medius and tensor fasciæ femoris from the outer surface of the iliac bone

In all operations of this class, some type of corrective appliance must be used in order to retain the part in the corrected position and to allay the painful muscular spasm which otherwise develops. Plaster of Paris is most suitable for the region of the ankle joint, while in the case of the knee and hip joint some type of adjustable splint is preferable.

Muscle and Tendon Transplantation

If a spastic muscle by reason of its persistent contraction, is pro-

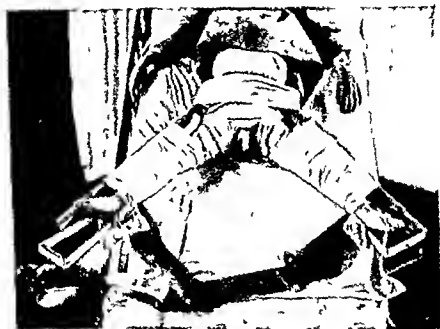


FIG 483—Double Extension

A double Hamilton splint altered so as to provide double extension after the operation of division of the adductors in the treatment of Little's disease

ducing a deformity of the part it is apparent that the muscle insertion may be transplanted to a new attachment so that its hyper-tonic influence is exerted as a means of correction of the deformity. The principle is put into use in many cases of spastic deformities.

Ankle-joint deformities are unsuitable for this type of operation but at the knee a spastic biceps may be transplanted into the patella for correction of a flexed knee. At the hip, no muscle or tendon transplantation has been attempted successfully.

It is in the upper extremity that transplantation operations find their greatest sphere of usefulness. At the shoulder joint, when there is considerable internal rotation of the humerus, transplantation of the

subscapularis combined with division of the pectoral tendons may yield a good result. In the forearm, persistent pronation is corrected by transplantation of the pronator radii teres together with the flexor carpi radialis into the posterior surface of the radius (Tubby), or the pronator is transplanted into the extensor carpi radialis longior and brevior tendons (Jones). The latter operation has the advantage of not only correcting the exaggerated pronation, but of reinforcing the weakened extensors of the wrist.

The deformity of wrist flexion with hyperextension of the fingers at the metacarpo-phalangeal joint, ulnar adduction of the hand, and adduction of the thumb is improved by transplanting the tendon of the extensor carpo ulnaris into the three extensor tendons acting on the thumb (Jones and Lovett).

Severe palmar flexion deformity is improved by transplantation of the pronator radii teres into the tendons of the extensor carpi radialis longior and brevior, and the implantation of the flexor carpi ulnaris tendon into the extensor carpi ulnaris (Jones and Lovatt).

The after-treatment of cases of this description is similar to that described in connection with tendon transplantation for infantile paralysis.

B. Operations on the Nervous System

1 *The Induction of a temporary Paralysis of the Spastic Groups by Nerve Crushing or by Alcohol Infiltration.*

If a temporary paralysis extending over three or four months can be guaranteed in the spastic groups, an opportunity is afforded of so developing the opposing and hitherto weaker groups that, when recovery of power returns, the muscular balance is more efficiently adjusted. Such a temporary paralysis is secured by infiltration of the nerves with alcohol or by crushing of the nerve with blunt forceps; the latter method is to be preferred, as it affords a longer period of paralysis.

It is only in certain localities that the manœuvre is possible—the obturator nerve at its exit from the pelvis, the branches of the internal popliteal supplying the soleus and gastrocnemius muscles, the anterior tibial nerve, and the hamstring branches of the sciatic nerve. Complete paralysis, both motor and sensory, follows interference with the nerve.

2 *Weakening the Power of Spastic Muscles by the Division or Crushing of the Motor Fibres to Individual Muscles or Muscle Groups (Stoffel's operation).*

Motor fibres to individual muscles leave the main trunk at different points, the positions of which are more or less constant. In Stoffel's operation the motor branches are exposed, identified by an electric needle, and resected. An immediate relief of spasm results, and, thereafter, exercises to develop the hitherto weaker muscles are begun

while deformities are corrected and the parts retained in the corrected position

3 *Resection of the Posterior Nerve Roots (Foerster's operation)*

The purpose of this operation is to check the afferent impulses from the periphery that excite muscular activity and thus to ensure better co-ordinated control of the part. The operation consists in laminectomy and division of the posterior nerve roots, dorsal to the ganglia.

In spastic paraplegia the nerves concerned are the four lower lumbar and the two upper sacral—all the roots are divided with the exception of the first and third lumbar nerves these being concerned in the supply of the anterior thigh groups, which it is important to conserve. In the upper extremity, the four lower cervical and the first dorsal are the nerves involved.

It is apparent that the operation is necessarily a very severe one, and while good results have been reported the tendency is to abandon it for the less serious peripheral types of operation.

4 *Sympathetic Ramisection (Royle and Hunter's operation)*

Believing that the rigidity of spastic muscle is an exaggerated manifestation of the 'plastic' change first described by Sherrington in the peripheral muscles of decerebrate animals and being convinced that the 'plastic' or tonic function is peculiar to certain muscle fibrils supplied by non-medullated sympathetic nerves Royle and Hunter have employed the operation of sympathetic ramisection in the treatment of spastic extremities. The operation is a highly technical one, and the results available are not yet sufficiently numerous to speak with confidence of the results.

In an affection of the lower limbs, the lumbar sympathetic is exposed by an incision which extends from the last rib to the crest of the ilium and thence forwards to the anterior superior spine of the ilium. The sympathetic cord is ultimately exposed and ramisection by avulsion is performed on the rami communicantes of the second, third, and fourth lumbar nerves, thereafter the main ganglionated cord is divided at a level corresponding in position to the fourth lumbar nerve. By this means there is no serious interference with the sympathetic supply to the abdominal viscera.

In paralysis of the upper extremity, the field of operation is reached through an incision extending from the clavicular insertion of the sterno-mastoid backwards and upwards across the posterior triangle. The rami communicantes of the fifth, sixth, seventh and eighth cervical and first dorsal nerves are avulsed, the main sympathetic trunk is not interfered with.

It is claimed that immediate improvement follows the operation, but the authors insist on careful post-operative educative measures.

5. Cerebral Decompression.

In 1913 Sharpe reported a series of 236 cases of spastic paralysis which he had treated by cerebral decompression on the basis that lumbar puncture and ophthalmoscopic examination showed evidence of



FIG. 484.—Intra-uterine Amputation of left Forearm (Boy 9 years)
A vestigial phalanx is attached to the stump.

increased intra-cranial pressure. In all but thirteen cases improvement was noted. It is suggestive, however, that Sharpe advised tendon lengthening and muscular re-education as part of the post-operative treatment, and the view at present held is that no real benefit follows the operation of cerebral decompression.

CHAPTER XXXVIII

THE SURGERY OF THE UPPER EXTREMITY

CONGENITAL MALFORMATIONS OF THE ARM AND HAND

THE DEVELOPMENT OF THE UPPER EXTREMITY

The first appearance of the extremities is in the shape of small rounded buds springing from the lateral aspect of the trunk at the junction of its dorsal and ventral aspects. The buds are first visible at the end of the third week, and as they grow they become flattened so as to present surfaces which lie parallel to the vertical antero posterior plane of the trunk. At the end of the fifth week a constriction appears which corresponds to the position of the wrist joints, and divides the original projections into hand and arm plates.

At the circumference of the hand plate, a thickened border (the digital pad) makes its appearance, and from this pad a series of projections develop into the thumb and fingers.

Differentiation of the mesoblast within the limb buds results in the formation of the various osseous and articular structures.

As the limb elongates angulation appears by the formation of joints between the four main elements of it, at the shoulder or hip, elbow or knee, wrist or ankle. The first and third of these open outwards, the second opens inwards. Flexion or torsion of the limb now ensues, and it is a distinction of the process as it affects the two limbs which leads to the differentiation of fore limb and hind limb. Each limb is twisted through two thirds of a circle, a backward flexion in the case of the fore limb so that the elbow is directed towards the tail end of the body, and a forward flexion of the hind limb so that the knee is directed forwards.

A further secondary change occurs in the fore limb, for the fore arm and hand are subjected to a form of rotation (pronation) by which the radius is made to overlap the ulna.

Gegenbauer believes that the development of the extremities is arranged on the plan of the *primitive fin*, as a stem and four independent rays.

Congenital Absence of Extremities

Congenital Absence of Extremities—Congenital Amputation—Constricting Bands

The malformations which arise from congenital absence of the extremities may be grouped into one or other of the following divisions—*Ectromely*, *Hemimely*, and *Phocomely*. These terms demand a word of explanation.

Ectromely refers to the complete absence of one or more extremities. The deformity is usually bilateral in its distribution.

Hemimely is descriptive of the congenital absence of the distal segment of an extremity—the limb terminating in a stump which may be surmounted by an imperfectly developed digit.

Phocomely is an exceedingly rare deformity in which the proximal



FIG. 485.—Constriction Bands on Fingers, the result of amniotic bands.

segments of the limb are absent, and the hand (or foot) is directly attached to the trunk. This error is usually bilateral.

The practical importance of such deformities as *ectromely* and *hemimely* is the relationship which they bear to the cases of so-called *intra-uterine amputation*. The absence of an extremity in whole or in part may be an evidence of arrested development, or it may proceed from intra-uterine amputation. It is said that a distinction may be drawn by observing the appearance of the stump, the existence of a terminal digit indicating a primary arrest of development.

Spontaneous intra-uterine amputations, implying no primary defect of the germ cell must be grouped as examples of secondary congenital deformities. The influences producing the error are such as constriction by the umbilical cord, presence of amniotic bands, scar formation following skin infection, gangrene of the limb following fracture, or thrombosis.

Incomplete examples of the error are met with in those cases in

which there is a deep circular constriction around the extremity, the result evidently of an amniotic band. Swelling of the distal parts usually accompanies the deeper degrees of limb constriction.

TREATMENT If the extremity is partly or entirely absent, treatment resolves itself into the fitting of a useful prosthetic apparatus. Constricting bands require a plastic operation. The sulcus is excised



FIG 486 —Syndactylism and Congenital Constriction
(Baby 8 months old)

as far as the subcutaneous tissue by circular incisions above and below the groove, the edges are afterwards united.

ANOMALIES OF THE BONES

Congenital Malformations of the Clavicle

DEVELOPMENT The centre for this bone evident in the sixth week, precedes all others, and the fact that it develops in indifferent tissue before any trace of the bone outline is to be seen has given rise to the view that the bone is developed in membrane. A cartilaginous outline appears which is soon involved in the ossifying process, about the seventeenth year a centre is formed in the sternal epiphysis and the epiphysis joins the shaft about the eighteenth or nineteenth year.

Bifid Clavicle This is a rare congenital error of which we have

seen a solitary example. The malformation gave rise to an irregularity in the bony outline, but the condition has no practical significance or importance.

Congenital Absence of the Clavicles. A number of cases of defective formation of the clavicle on one or both sides are recorded. In most instances, a portion of the sternal extremity is present. The defect appears to cause but slight inconvenience.

The rare hereditary abnormality known as *cleido-cranial-dysostosis* is associated with imperfect formation of one or both clavicles. The characteristic clinical features of these cases are (a) an exaggerated development of the transverse diameter of the skull, (b) delayed ossification of the cranium, and (c) more or less extensive aplasia of the clavicles (Thomson).

There are varying degrees of structural change in the clavicles, one or both bones may be entirely absent, in most cases the sternal ends are present, sometimes the central part only is absent.

Owing to the clavicular defect, an abnormal range of movement is possible at the shoulder girdle. Short stature and static errors of the skeleton often accompany the deformity.

The absence of the clavicles in the arrangement of the shoulder girdle permits a remarkable freedom of movement in this region, so that an individual may be able to approximate the points of opposite shoulders, yet the peculiarity has apparently no very serious effect upon the subsequent weight-bearing and strength of the parts.

Congenital Elevation of the Scapula

Congenital High Scapula—Sprengel's Shoulder. About the fifth week of development, the scapula becomes differentiated in the mass of mesoblastic tissue which lies opposite the fourth, fifth, sixth, and seventh cervical vertebræ. Towards the end of the ninth week it begins to descend to an upper thoracic level, and by the third month it has reached its ultimate position, its upper border being on a level with the second dorsal spine. If, for reasons to be discussed, the descent of the bone is prevented, the condition is described as a *congenital elevation of the scapula—Sprengel's shoulder*, or *congenital high scapula* (Greig).

VARIETIES. Greig suggests that cases of congenital high scapula may be divided into—

1. Those which are isolated or uncomplicated (*scapula alta vera*).
2. Those in which an abnormal omo-vertebral attachment is present.
3. Those associated with adjacent abnormalities in the cervico-dorsal spine or in the ribs.
4. Those in which the mutual symmetry of the scapulæ is not interfered with, but the difference in level is dependent upon some more or less remote congenital defect, such as congenital scoliosis of the dorsal spine or low lumbar asymmetry.

PATHOLOGY In addition to the abnormally high position, the bone is altered in its axis outline and size. The elevation is usually accompanied by rotation so that the lower angle is brought nearer to the spine, the bone is shortened so that the transverse diameter approaches or exceeds the vertical, the upper border is bent forwards so that it may project in the supra clavicular region, the sub-scapular angle is increased, and the coracoid process is usually shortened and deformed.

If an omovertebral connection exists, it takes the form of a



FIG 487—Congenital high Shoulder
(Sprengel's shoulder)

An example of the deformity in a boy 7 years old

bony, cartilaginous or fibrous band extending from the superior median angle or upper third of the vertebral border of the scapula to the transverse process of one of the lower three cervical vertebrae. If the connection is an osseous one, it exists as a triangular-shaped bone with the base at the scapula and united to the related parts at one or both ends by cartilage or bony union. In certain cases, a spine like process of bone projects upwards and medially from the superior angle of the scapula without establishing contact with the spine.

Associated malformations of other parts may affect the spine or the ribs.

In the spine, absence of differentiation of the vertebræ resulting in *brevi-collis* may occur; in the ribs there may be congenital absence of ribs or fusing of individual bones.

The association of cervical ribs with congenital high scapula has been described; the association has been well explained by Greig, and

we quote his words. After an account of the phylogenetic and ontogenetic aspects of the question, he says:—

‘Congenital high scapula is not situated high in the neck *because* of the presence of cervical ribs, but the cervical ribs have developed because, the scapula not having descended to the thorax, the usual obliquity or strain has not been put upon other structures—notably on the nerves of the brachial plexus.’

ETIOLOGY. Sprengel believed that intra-uterine pressure was responsible for the deformity, but this view is not generally accepted. Whatever the cause may be, it must be exerted at a comparatively early period in development, certainly before the fourth month. In the uncomplicated variety of the deformity, a congenital neuro-muscular error is



FIG. 488.—Congenital high Scapula (Boy 10 years old)

Appearance of the deformity from the front.

probably the responsible factor. It is most likely a functional disability, as no structural change has been discovered in the muscular tissue.

In cases in which an omo-vertebral connection exists, it is natural to assume that this structure has been the fixing agent—the omo-vertebral band resulting from an imperfect differentiation of the supra-scapular mesoblast and the conversion of this tissue into cartilage, bone, or fibrous tissue. When the high scapula is associated with congenital errors of the spine or ribs, there are many who consider the spinal or costal error the primary lesion, and the malposition of the scapula the secondary one.

CLINICAL FEATURES The elevation of the scapula is apparent, there is a raising of the shoulder on the affected side, and the rotation of the limb is interfered with.

Wryneck is an accompaniment of the disorder in about 10 per cent of cases. Some degree of scoliosis accompanies every unilateral case. The deformity is bilateral in a small proportion of cases.

DIAGNOSIS The physical signs and X ray appearances of a typical case are characteristic. Congenital high scapula may be simulated by other conditions. Tuberculous disease of the cervico dorsal spine with much destruction of the vertebrae may result in an acquired *brevicollis*.



FIG. 489.—Congenital high Scapula (Sprengel's shoulder) (Girl 10½ years old).
A congenital high scapula of the right side. The interference with full elevation of the arm is illustrated.

which at first sight suggests a bilateral congenital elevation of the scapulae.

It is obvious that a high scapula may be acquired, as in extreme degrees of dorsal scoliosis. Trevor has described an example of hysterical elevation of the scapula which closely simulated the congenital type.

PROGNOSIS An early case is probably improved by exercises but in the absence of operation no marked improvement is likely. The wage earning capacity of the individual is unlikely to be interfered with.

TREATMENT Early cases should have the benefit of exercise.

treatment, and in several instances we have noted that improvement has followed.

If operation is decided on, it should be undertaken in early infancy before the soft tissues have become accommodated.



FIG. 490 —Congenital Ulnar Club Hand.

The result of congenital absence of the lower ends of the ulnæ. There is also a double congenital talipes and congenital absence of the patellæ

In uncomplicated cases, operation implies the exposure of the upper border of the scapula, the detachment of the related muscles and the removal of the distorted upper border of the bone. The scapula is thereafter forced downwards into its natural position, and secured there by suturing the upper scapular edge to an underlying rib.

It is doubtful, however, if operation affords any real benefit in uncomplicated cases, as the amount of scar tissue which results is apt to interfere with subsequent movements of the bone. Brachial paralysis of a temporary character is apt to follow operation.

In cases which possess an omo-vertebral connection, the fibro-ossaceous band should always be removed.

No operative interference is indicated in cases associated with congenital errors of the spine or ribs.

Congenital Defects of the Humerus

Independent defects of this type have not been recorded. There is, of course, congenital absence of the bone, in whole or in part, in those cases in which the upper extremity is absent.

Congenital Defects of the Radius

Anomalies of this type are occasionally met with, total absence of the bone is rare. The degree of the defect varies in extent—only a small segment of the upper end may exist, or the bone may be complete except at its distal extremity, in rare cases the middle third of the shaft is absent. Whatever the extent of the error, a permanent congenital deviation of the hand invariably co exists. The error is usually unilateral.

Congenital Defects of the Ulna

This is a much rarer event than a similar condition in the radius. Kinnell has reported a series of cases, thirteen in number. Any part of the ulna may be absent and an associated ulnar club hand is usually present.

Club Hand

The term club hand is used to describe a permanent deviation of the hand in relation to the forearm. According to the type of the deviation we speak of club hand as being radial, ulnar, palmar, or dorsal, or any obvious combination of these terms.

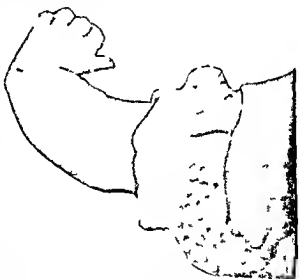


FIG 491 —Club Hand with congenital absence of the Radius (Baby 4 months)

The condition of the bones of the forearm varies in different types of the deformity—the usual event is to find the distal end of the radius or ulna absent, but, in other cases, the bones of the forearm may be normal or show an exaggerated degree of curvature.

ETIOLOGY The origin of the error is a matter of conjecture. Roberts has described two cases of radial club hand in which at birth the affected hand was tucked into the axilla. As he expressed it 'We had very little doubt that the faulty position of the hand was the direct cause of the developmental error.'

PATHOLOGY In addition to the deviation of the hand, the digit on the side towards which the hand is deviated is often absent—the thumb in radial club hand, the little finger in ulnar club hand. The carpal bones on the side of the deformity are usually absent or abnormal in outline, and the musculature of the part is deranged, particularly in those cases in which a digit is absent.

CLINICAL FEATURES. The symptoms vary with the type and degree of the deformity. Many individuals acquire a wonderful degree of



FIG. 492.—Congenital Club Hand with congenital absence of Radius (Baby 1½ years old).

The left hand has been operated on, the right hand is in its original condition

usefulness in the functional powers of the arm. The whole development of the arm is retarded, and of course the appearance is most unsightly.



FIG. 493.—Congenital Club Hand.

The condition is bilateral, and there is congenital absence of the lower ends of the radii.

In certain cases there is an associated error in the development of the pectoral muscles, and McGuire has alluded to the frequency with which congenital heart lesions accompany the brachial error.

TREATMENT. If the case comes under the surgeon's care at an early stage, a considerable degree of improvement may be secured by manipulation and stretching of the part, and the wearing of a corrective splint.

Operative measures are often disappointing. Osteotomy of the existing bone may permit replacement of the hand, and this measure may be

necessary as a preliminary to more radical measures. A bone graft may be inserted between the middle of the shaft of the existing bone and the carpus so as to maintain the hand in a correct position (Albee), or the end of the existing bone may be inserted into the centre of the carpus (Sayre), or the lower end of the existing bone may be split and the carpus fastened into the gap (Bardenheuer).

Cleft Hand

(*Lobster claw hand—Main fourche*)

A defect may exist in which, as the result of absence of the middle digit, with or without the related metacarpal, the hand acquires a cleft appearance. In most examples of this deformity, the number of digits is increased.

The defect is usually hereditary, and it is more often double than single. There is a great variety in the arrangement of the bones.

TREATMENT A plastic operation may be carried out, but if the function of the hand is good, it is wiser to leave the deformity alone.

Congenital Radio ulnar Synostosis

Congenital Pronation

Congenital radio ulnar synostosis is a rare congenital error in which the most obvious feature is an inability to hold the hand supine. The error consists in an ankylosis of the upper ends of the radius and ulna, the bones being arranged in a semi-pronated position.

ETIOLOGY There is general agreement on certain negative points—that the condition is due neither to intra uterine injury, nor to the repression of some extraneous agency, nor to intra uterine inflammation. It is apparently a constitutional error, the result of an imperfect separation of the cartilaginous axials which form the bones of the forearm.

The ontogenetic development of the bones of the forearm has been studied by Dr W. H. Lewis. He showed that in the earliest pre cartilage stage there is a single mesenchymatous plate from which radius, ulna and humerus are later derived. This mesenchymatous plate is



FIG 494.—Congenital Radio ulnar Synostosis (Boy 10 years)

later replaced by three cartilaginous rods for humerus, radius, and ulna respectively. About the fifth week, the arms are turned towards the ventral side of the trunk so that the palms become applied to the chest. In this position, the forearm occupies a position midway between pronation and supination, the radius lying so that its proximal end is ventral to the ulna while the distal end is dorsal.

In the normal case, the process of chondrification which produces the outline of the radius and ulna is arrested at such a stage that mesenchymatous tissue separates the parallel bones at all points. In the synostotic case, chondrification and ossification extend across the intervening mesenchyme at that point at which cartilaginous axials lie close to each other—the proximal end.

Secondary Factors. It is obvious that there must be some factor which controls the development of the synostosis, for it is merely begging the question to suggest that it is an 'accident.' The records of Abbott, Wilson Boorstum, and others have shown that in some instances the disease is an inherited condition, and the results of Nelson's investigations indicate that synostosis is a dominant Mendelian characteristic. There is evidence, therefore, that in some instances hereditary or chromosome influences are at work.

A second possible factor has relation to the influences which control the chondrification and ossification of the skeleton. Many of the affected individuals have been short in stature and a certain proportion have suffered from exostoses. Now both these features indicate a derangement of the normal process of bone growth, and the coincidence of their occurrence with radio-ulnar synostosis would indicate an ossification error centred in particular bones. In about 50 per cent. of the cases, the error is bilateral.

CLINICAL HISTORY. It is recorded that, since early childhood, the individual has been unable to turn the palms of the hands upwards so as to receive an object; in other words, that supination has been impossible. Pronation is usually present over a range which varies from 90 to 120 degrees, flexion is normal, but extension is limited. Weights are lifted and carried in a characteristic fashion, the object being borne on the radial side of the hand. The disability does not materially interfere with function except in such movements as the use of knife, fork, and spoon. The muscular development of the limb is good, but the extremity is somewhat shorter than normal.

In later life the individual may complain of pain at the elbow when weight-lifting is attempted.

Types of Radio-ulnar Synostosis. The osteogenic defect is not a simple uniform one; on the contrary, it varies in degree and in type.

A. In the least modified type, the shape of the radius is practically unaltered but the bone is more curved than usual and the head is united by osseous tissue to the ulna in the region of the lesser sigmoid fossa.

B. The second type is sometimes spoken of as 'the headless type.'

The upper end of the radius shows no definite moulded head and the upper end of the radius shaft is attached to the lateral aspect of the ulna



FIG 495—Congenital superior Radio ulnar Synostosis
The radiographic appearance of an example of the disease in boy 8 years old

C The third type is known as the 'dislocated head' type. The head of the radius is reasonably well developed, but it is displaced

backwards or forwards—more frequently forwards. The upper part of the shaft is fused to the ulna in the region of the coracoid process. This type of the deformity is usually unilateral and it is frequently associated with other congenital errors such as supernumerary thumb, absence of thumb, or syndactylism.

TREATMENT. The advisability of operative treatment has been questioned by many, and as Lieblein has pointed out, the handicap which this deformity entails is less to the patient, in so far as he has never known the advantages of supination of the forearms, and he is therefore in a very different position from the patient who has acquired a radio-ulnar synostosis.

The operation which meets with the greatest degree of success is that which removes the head of the radius together with the interosseous ridge. The best access is secured by an incision which extends along the subcutaneous surface of the ulna from the olecranon process downwards for 3 inches. The dissection is carried subperiosteally along the radial border of the ulna and outwards on the interosseous bridge until the radial head is exposed. By this route all possibility of injuring the interosseous nerve is avoided. After removal of the head and the interosseous bridge, free movements are instituted in case post-operative fixation should occur.



FIG. 496 — Congenital Synostosis of superior Radio-ulnar Joint (Baby aged 9 months)

Congenital Dislocations of the Joints of the Upper Extremity

The Shoulder Joint

Examples of true congenital dislocation of the shoulder joint are exceedingly rare. A study of the literature might seem to give a different impression, but statistics of the error are especially unreliable, because examples of traumatic dislocation and paralytic dislocation are so often confused with the true congenital error.

The cases which Scudder¹ published in 1890 and 1898 are generally accepted as undoubted examples of true congenital dislocation, and, as we have never had an opportunity of observing an example of this rare deformity, we report the facts which he recorded.

The cases were full time children, head presentation, and normal deliveries. The babies were healthy, there was no swelling, and no pain was elicited handling—in fact, the errors were overlooked by the doctors at birth, and only subsequently were detected by the parents. This fact is important, as it excludes the possibility of birth traumatism. When the error was discovered, electrical stimulation of the muscles showed no evidence of paralysis. In each instance the displacement was a sub spinous one, the arm being deformed in a position of internal rotation with slight flexion at the shoulder joint, the elbow being abducted and slightly flexed. There was considerable limitation of movement, and the head of the humerus could be felt beneath the spine and behind the acromion process. Subsequent operation showed a small scapula, atrophy of the glenoid with imperfect excavation, wasting of the head of the humerus, abnormal laxity of the capsular ligament and adhesions within the joint.



FIG 497—Congenital Radio ulnar Synostosis (Boy 8 years)

The condition was a bilateral one. The left arm has been operated on and some improvement obtained. The right arm remains synostosed.

The cause of the displacement is problematical. Many believe that it results from muscular action combined with pressure exerted by the uterus.

¹ Scudder C. L. *Arch of Pediatrics* Vol VII p 260 1890. *Amer Journ Med Sci*, New Series Vol CXV, p 125 1898.

THE TREATMENT followed in the majority of the recorded cases has taken the form of reduction by open operation and a plastic operation on the lax capsular ligament designed to prevent a recurrence of the displacement.

Congenital Dislocation of the Elbow

Examples of congenital dislocation of the elbow joint are occasionally met with. Anything approaching a complete dislocation is an exceedingly rare event. In the majority of the recorded cases a partial luxation of the head of the radius has been the extent of the error. When a more complete displacement occurs there is usually a coincident deformity of the related bones, and in this event the displacement may be backward, forward, or lateral.



FIG. 498.—Congenital Dislocation of Metacarpophalangeal Joints of the left Hand (Baby $1\frac{1}{2}$ years old).

The function of the elbow joint may be seriously compromised by the deformity—mobility is restricted, particularly in the directions of supination and extension.

TREATMENT. X-ray examination will determine the character of the deformity and the influence which it exerts upon the function of the part. With this knowledge it may be possible to design and carry out the removal of a bony structure which is interfering with movement. Resection of the head of the radius, for example, may greatly improve the function.

Congenital Dislocation of the Wrist

Apart from the deformity which occurs in association with club hand, congenital dislocation of the wrist is exceedingly rare. Several examples of bilateral dislocation have been recorded in German literature.

Spontaneous Subluxation of the Wrist

*(Malgrine's or Madclung's deformity)*Curved Radius (*Destot*)

This deformity is occasionally seen in children, it consists in a peculiar displacement of the hand in a palmar and radial direction—a forward subluxation of the carpus, in fact

The error primarily depends upon a change in the lower radial epiphysis, this acquires a bend in a palmar direction, so that the articular surface looks downwards and forwards instead of directly downwards. Palmar displacement of the carpus is the natural result, while the unchanged ulna remains as an unusually prominent landmark on the dorsum of the wrist. There is an abnormal separation between the bones of the forearm at the wrist, the ligaments are relaxed, and the actual bony outline of the lower end of the radius and ulna are increased in size.

ETIOLOGY The deformity usually begins about the twelfth year, and thereafter increases in degree for several years. For some unknown reason its occurrence is more frequent in girls than in boys. It is suspected that a congenital laxity of the wrist ligaments, combined with an acquired rachitic deformity, are the predisposing factors. Occupational influences and injury are the probable exciting causes.

CLINICAL FEATURES Sensations of weakness and discomfort are complained of around the joint. The wrist is often described as 'feeling loose'. Dorsal flexion of the hand is restricted, and, if the deformity is extreme, pronation and supination are limited.

TREATMENT Rest, massage, forcible manipulation of the hand into a dorsiflexed position and the retention of it in this position in a suitable splint constitute the usual methods of treatment. In severe cases osteotomy of the radius may be considered.

The prospects of cure are unfavourable unless the condition has been recognized at an early stage.

Cubitus Valgus and Cubitus Varus

When the arm is fully extended in the supinated position, the forearm forms an outward open angle with the upper arm of 165 to 170 degrees. This is known as the 'carrying angle,' and the exaggeration or the diminution of this angle constitutes the deformities of cubitus varus and cubitus valgus respectively. *Cubitus varus* is an adduction of the forearm to the ulnar side, *cubitus valgus* is a deviation of the forearm to the radial side.

ETIOLOGY Laxity of the ligaments is the cause of the congenital type of the deformity, the acquired deformities arise as the result of fractures or injuries to the epiphysis which lie in relation to the elbow joint.

TREATMENT If the deformity is severe enough to be unsightly or

THE TREATMENT followed in the majority of the recorded cases has taken the form of reduction by open operation and a plastic operation on the lax capsular ligament designed to prevent a recurrence of the displacement.

Congenital Dislocation of the Elbow

Examples of congenital dislocation of the elbow joint are occasionally met with. Anything approaching a complete dislocation is an exceedingly rare event. In the majority of the recorded cases a partial luxation of the head of the radius has been the extent of the error. When a more complete displacement occurs there is usually a coincident deformity of the related bones, and in this event the displacement may be backward, forward, or lateral.



FIG. 498.—Congenital Dislocation of Metacarpophalangeal Joints of the left Hand (Baby $1\frac{1}{2}$ years old).

The function of the elbow joint may be seriously compromised by the deformity—mobility is restricted, particularly in the directions of supination and extension.

TREATMENT. X-ray examination will determine the character of the deformity and the influence which it exerts upon the function of the part. With this knowledge it may be possible to design and carry out the removal of a bony structure which is interfering with movement. Resection of the head of the radius, for example, may greatly improve the function.

Congenital Dislocation of the Wrist

Apart from the deformity which occurs in association with club hand, congenital dislocation of the wrist is exceedingly rare. Several examples of bilateral dislocation have been recorded in German literature.

broad, the best operative method consists in division of the web and the turning in of a V shaped flap taken from the dorsum between the roots of the fingers. The divided edges of the web are split, and the edges sutured without tension.

When the web is narrow, a perforation is made through the base of the web between the fingers, and this is lined with epithelium by tunnelling flaps of skin taken from the dorsal and palmar aspects through the opening. The flaps are sutured lightly in place, and the aperture is kept patent with a glass rod until it is completely epithelialized. At the end of

five or six weeks, the tunnel is sufficiently perfect to permit of the web being split vertically into the channel. The space between the



FIG 500 —Congenital Constrictions of Limb

The foot of a new born baby showing the circular constrictions and intermediate swellings which have resulted from annulotic bands



FIG 501 —Polydactylism in left Hand

There is an additional little finger

fingers is thereafter kept packed with dressing, and the scars of the fingers are allowed to heal by granulation.

Polydactylism

This is one of the most frequent congenital malformations, it is often hereditary, and the error may be continued through several generations.

to interfere with the use of the part, it may be remedied by an osteotomy of the lower part of the shaft of the humerus.

Contractions and Deformities of the Fingers

Congenital Contraction of the Fingers (Hammer Finger). Children are occasionally affected by a congenital contraction of the little finger of one or both hands. In rare exceptions, several fingers may be affected. The deformity has a strong hereditary tendency. The digit is held semi-flexed, and there is a shortening of all the soft tissues on the flexed side; the joint may be subluxated.

TREATMENT. If treatment by manipulation and splinting is begun early, the deformity may be corrected. In more resistant cases, lengthening of the contracted tissue becomes necessary.



FIG. 499.—Congenital Dislocation of the Thumb.

The head of the metacarpel bone is deformed and the phalanges are virtually dislocated upon its outer surface.

Webbed Fingers (Syndactylism). In this comparatively common deformity two or more fingers are united by skin and fibrous tissue over a varying extent. The web varies from a thin diaphragm composed of skin and subcutaneous tissue to a thick band containing muscular fibres from the opposed parts; occasionally the bones of the fingers may be united, and even the adjacent finger-nails may coalesce.

The cause of the error is arrest of development before the fingers become separated from one another, hence the thumb, which is differentiated as early as the seventieth day, is rarely affected, while the fingers, later in their separation, are involved.

TREATMENT. In all but the most extreme degrees, the fingers should be separated from one another by a plastic operation. The scheme adopted will vary according as the web is wide or narrow. In the former case, where the fingers lie well apart and the web is

CAUSES OF THE PARALYSIS

There is general agreement that damage to the cords of the brachial plexus by stretching is the cause of the paralysis, the injury varying from a simple stretching to an actual tearing of the nerve fibres. In 1912 Lange put forward the view that tearing of the capsule of the shoulder joint was the feature responsible for the symptoms, and his view was supported by Thomas (1914), who claimed that, not only was there a tearing of the capsule, but that a dislocation of the humeral head occurred. Recent investigation, and particularly the experimental work of Sever, has shown that traction upon the arm and shoulder



FIG. 503.—Erb's Paralysis

The child is suffering from an obstetrical paralysis of the Erb-Duchenne type in both arms

is capable of damaging the nerve roots and that other injuries, if they exist, are of secondary importance

VARIETIES AND PATHOLOGY

VARIETIES If downward traction is exerted on the arm so that the shoulder is separated from the neck, the tension thereby induced is borne by the fifth and sixth cervical roots, and the paralysis which results affects the deltoid, supra- and infra spinatus, biceps, coraco brachialis, the supinators of the forearm, and, in part, the pectoralis major—the collective lesion is spoken of as '*the upper arm*' type of paralysis or the '*Erb Duchenne*' paralysis

If the arm is pulled upwards above the head, as may happen in a breech presentation the tension effects are likely to be borne by the eighth cervical and first dorsal roots and, as these roots are concerned

The supernumerary fingers may be perfect in their formation, or they may be imperfectly formed appendages added to a normal hand.



A



B.

FIG. 502.—Example of Polydactylysm in Hand and Foot (Child aged 4 months).

A Example of accessory thumb.

B A triple great toe in the right foot.

TREATMENT. If the error is unsightly, or interferes with function, the supernumerary finger or fingers should be removed.

OBSTETRICAL PARALYSIS

Partial or complete paralysis of the muscles of the arm may develop in newly-born children, and, as disabilities of this type generally appear after a prolonged and difficult labour, they are spoken of as *obstetrical paralyses*.

the fingers may be hyperextended, while the distal ones are flexed. If the damage to the first dorsal root is severe, the oculo pupillary fibres in the communicating branch to the stellate ganglion may be injured with resulting inequality of the pupils.

In the *whole arm type*, where it must be assumed that all the roots of the plexus have been damaged, the paralysis is often erratic in its distribution, but forearm and hand paralysis is apt to be more extensive in this type of lesion.

Sensory Changes. So far as is known, no sensory disturbance accompanies the upper arm type, but, in the lower arm type, sensory and even trophic changes may occur, because the eighth cervical and



FIG. 505.—Obstetrical Paralysis of the Erb-Duchenne Type

The distribution of the paralysis in the right arm and the resulting deformity are characteristic.

first dorsal roots are intimately concerned with the distribution of the sensory branches of the radial, median and ulnar nerves.

After some weeks the tenderness which has been present around the shoulder joint disappears.

It is exceptional for the paralysis to be complete, and, as time goes on, there is a considerable degree of spontaneous recovery, even in the absence of efficient treatment. The degree of muscular wasting is often surprisingly slight and is chiefly manifest in the lower arm type.

DIAGNOSIS

Mistakes may arise through confusing obstetrical paralysis with the muscular weakness which accompanies birth injuries to the shoulder joint or humerus. Fracture of the clavicle, separation of the upper end of the humerus, tearing of the capsular ligament and traumatic

with the long flexors and extensors of the fingers and the small muscles of the hand and fingers, the resulting paralysis is spoken of as a 'lower arm' type or '*Klumpke*' type.

If the exciting cause has been of unusual severity, all the cords of the plexus may become involved, and a 'whole arm' type of paralysis result.

Bilateral types have been described.

PATHOLOGY. While in severe cases the nerve roots may be torn across, the injury is usually limited to the sheath, but hæmorrhage and

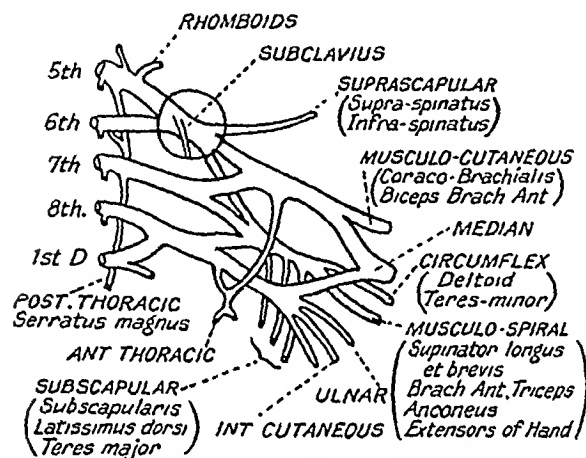


FIG. 504.—Obstetrical Paralysis (Upper Arm Type).

Schematic diagram illustrating the distribution of the brachial plexus. The ring indicates the common situation of injury.

effusion are invariably present. It is the pressure of these on the nerve fibres which produces the paralysis. In the later processes of repair, the formation of scar tissue may also play a part.

The exact situation of the lesions is generally close to the point of exit of the nerve roots from the vertebral column, and in some cases the damage may actually occur within the vertebral canal. In long-

CLINICAL FEATURES

Soon after birth it is observed that the arm hangs by the side, and, if it is handled or moved in any way, the child cries. The arm takes up characteristic positions according to the situation of the injury. In the *upper arm type*, where the fifth and sixth roots are involved, the arm hangs by the side in an attitude of internal rotation with pronated forearm, and it may be with flexed fingers and wrist (*the tip or porter hand*). The power of abduction and external rotation at the shoulder, of flexion and supination of the forearm are lost.

In the *lower arm type* (8th cervical and 1st dorsal) the wrist is 'dropped,' and the fingers are flexed; in some cases which apparently belong to the 'lower arm type,' the proximal phalanges of

the fingers may be hyperextended, while the distal ones are flexed. If the damage to the first dorsal root is severe, the oculo-pupillary fibres in the communicating branch to the stellate ganglion may be injured with resulting inequality of the pupils.

In the *whole arm type*, where it must be assumed that all the roots of the plexus have been damaged, the paralysis is often erratic in its distribution, but forearm and hand paralysis is apt to be more extensive in this type of lesion.

Sensory Changes So far as is known, no sensory disturbance accompanies the upper arm type, but, in the lower arm type, sensory and even trophic changes may occur, because the eighth cervical and



FIG. 505.—Obstetrical Paralysis of the Erb-Duchenne Type

The distribution of the paralysis in the right arm and the resulting deformity are characteristic

first dorsal roots are intimately concerned with the distribution of the sensory branches of the radial, median and ulnar nerves.

After some weeks, the tenderness which has been present around the shoulder joint disappears.

It is exceptional for the paralysis to be complete, and, as time goes on, there is a considerable degree of spontaneous recovery, even in the absence of efficient treatment. The degree of muscular wasting is often surprisingly slight, and is chiefly manifest in the lower arm type.

DIAGNOSIS

Mistakes may arise through confusing obstetrical paralysis with the muscular weakness which accompanies birth injuries to the shoulder joint or humerus. Fracture of the clavicle, separation of the upper end of the humerus, tearing of the capsular ligament, and traumatic

with the long flexors and extensors of the fingers and the small muscles of the hand and fingers, the resulting paralysis is spoken of as a 'lower arm' type or '*Klumpke*' type.

If the exciting cause has been of unusual severity, all the cords of the plexus may become involved, and a 'whole arm' type of paralysis result.

Bilateral types have been described.

PATHOLOGY. While in severe cases the nerve roots may be torn across, the injury is usually limited to the sheath, but hæmorrhage and

effusion are invariably present. It is the pressure of these on the nerve fibres which produces the paralysis. In the later processes of repair, the formation of scar tissue may also play a part.

The exact situation of the lesions is generally close to the point of exit of the nerve roots from the vertebral column, and in some cases the damage may actually occur within the vertebral canal. In long-

standing cases, the bones are atrophied, particularly the upper end of the humerus; in certain cases, a hooking of the acromion process over the head of the humerus has been described, an event which may interfere mechanically with abduction of the arm. Subluxation of the shoulder joint may also occur.

CLINICAL FEATURES

Soon after birth it is observed that the arm hangs by the side, and, if it is handled or moved in any way, the child cries. The arm takes up characteristic positions according to the situation of the injury. In the *upper arm type*, where the fifth and sixth roots are involved, the arm hangs by the side in an attitude of internal rotation with pronated forearm, and it may be with flexed fingers and wrist (*the tip or porter hand*). The power of abduction and external rotation at the shoulder, of flexion and supination of the forearm are lost.

In the *lower arm type* (8th cervical and 1st dorsal) the wrist is 'dropped,' and the fingers are flexed; in some cases which apparently belong to the 'lower arm type,' the proximal phalanges of

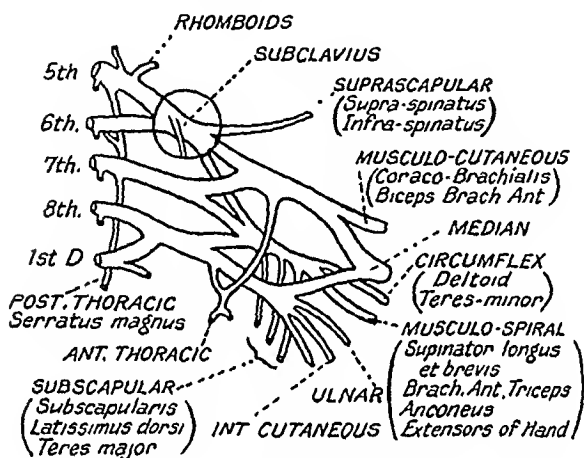


FIG. 504.—Obstetrical Paralysis (Upper Arm Type).

Schematic diagram illustrating the distribution of the brachial plexus. The ring indicates the common situation of injury

OPERATIVE TREATMENT

A stage is ultimately reached when it is apparent that conservative measures can do no more, and, if at this stage, deformity and paralysis still exist, the question of operative interference should be considered. There are several ways in which improvement may be secured.

Hoffa suggested and practised a transverse osteotomy of the neck of the humerus. This permits abduction and outward rotation of the humerus, and in some measure restores the power of useful movement in the upper arm. The method has never been widely practised.

Whitman, impressed by the existence of a posterior subluxation of the humerus head in many cases, recommends the replacement of the deformity by manipulation, the overcoming of any restriction to



FIG. 506—Erb's Paralysis (Baby 6 months old)

An example of Erb's paralysis of the left arm treated by an abduction rotation splint

the normal range of movement, the fixation of the part in plaster for a sufficient length of time to prevent relapse, and the subsequent restoration of function as far as is possible by massage, passive movement, and exercise. The criticism of *Whitman's* method is that the forcible manipulation is unnecessary in the milder forms of the disorder, while, in the extreme and fixed forms, the manoeuvre is either unsuccessful or is liable to cause damage to the upper humeral epiphysis.

The Sizer Fairbanks operation is, with us, the operation of choice, it is employed in cases where there are marked contractions, and where passive movement is impossible.

An incision is made between the deltoid and the pectoralis major, the tendon of the latter muscle is divided, and outward rotation of the humerus brings the insertion of the subscapularis into view as it lies

dislocation of the shoulder joint have therefore to be excluded. The diagnosis demands careful clinical investigation combined with X-ray examination.

PROGNOSIS

A considerable proportion of upper arm cases make a perfectly good recovery if judicious and careful treatment is arranged. None the less, the prognosis must necessarily depend upon the degree of damage to the nerve roots, for it is obvious that if there is severe stretching or actual tearing of the roots some degree of permanent paralysis will result. The possibility of severe damage appears to be greatest in the lower and whole arm types, and it is in these therefore that the prognosis is most serious.

With careful treatment, however, there is every prospect of a considerable amount of spontaneous recovery, while, even in the neglected and long-established cases, operative interference offers considerable chances of improvement.

TREATMENT

CONSERVATIVE MEASURES

If the maximum of success is to be obtained, treatment must be begun as soon as the condition is observed. The principle generally adopted is to fix the arm in a splint so that the muscles which are particularly weakened are kept relaxed. A type of platform splint is specially designed for this purpose; by it the arm is abducted to a right angle, the upper arm is rotated outwards, the elbow is flexed to a right angle, the forearm supinated and the wrist dorsiflexed. It is our plan to maintain the arm continuously in this position for two to three months, the splint being removed for purposes of washing.

If at birth there is such a degree of tenderness that manipulation would seem to be unwise, the arm is placed against the side, and the hand with the fingers extended is supported on the chest beneath the clothing. As soon as the more urgent symptoms have disappeared, the platform splint is applied.

After the period of complete fixation has passed, massage is begun, and the splint is removed at intervals each day to enable this to be done. At the end of a period, which may vary from six months to a year, the platform splint is abandoned, and the arm is carried in a sling, the wrist, which is generally the last part to recover, being still supported in the dorsiflexed position by means of a cock-up splint.

As the child grows older, muscular education is attempted; this is a matter of great difficulty in a young child, but progress may be made by teaching the child to reach for toys or to play simple games, efforts being particularly directed to encouraging voluntary movements of the affected muscles.

treated, to develop a contracture of the flexor muscles of the forearm, to which the names of *Volkman's contracture* and *ischaemic contracture* have been applied

ETIOLOGY If splint or bandage has been applied so tightly that insufficient allowance has been made for post traumatic swelling of the parts, and if the application is kept in place for several days, there is a prolonged interference with the normal circulation, so that an ischaemic necrosis of the muscles results. Too much importance, however, must not be attached to the influence of a local constriction, for, as Littlewood has shown, the condition may develop though no splint or bandage has been applied, in which case it is apparently secondary to intense swelling of the soft parts and possibly to rupture of the blood-vessels

PATHOLOGY When the error is established, the muscles which are affected become swollen, and, if exposed, they are found to be of a dark blue colour and firm in consistency. At a later stage they become wasted, contracted, and fibrous like. Histologically, the early appearance is a coagulation of the myosinogen of the muscle, and this change gradually passes into a formation of a fibrous tissue which ultimately replaces the muscle fibres

CLINICAL FEATURES The history usually given is that the child sustained an injury in the neighbourhood of the elbow joint, the arm was immobilized in splints, and, instead of the part being regularly inspected, the bandage was left untouched for several days. During that time no pain may have been complained of, but, if the band had been observed, it would have been noticed that the fingers were swollen, cold, and blue. When the splints are removed it is found that below the site of maximum pressure the forearm is swollen, the skin cold and bluish in colour, the flexor muscles contracted and incapable of voluntary movement. A slough extending through the skin may exist where the greatest amount of pressure has been exerted

In a fully established case the appearances are characteristic, the wrist joint and the metacarpo phalangeal joints are extended, the inter phalangeal joints are flexed, the hand is pronated, and the elbow joint is semi flexed. If the wrist joint is flexed the fingers can be extended. The hand feels cold, and the skin is shiny and blue in appearance. Sensation is normal, and the electrical reaction remains unaltered. The flexor muscles of the forearm undergo a rapid wasting, and contraction gradually develops. In long standing cases the bones are under developed, and the forearm becomes shortened in comparison with its fellow. In certain cases pressure upon peripheral nerves may result in interference with sensation according to the nerve or nerves which have been involved

DIAGNOSIS The contractures which follow anterior poliomyelitis and Little's disease may be confused with Volkman's contracture, but the history, clinical characters, and electrical reaction make the distinction clear

upon the joint capsule. The tendon of the muscle is picked up by an aneurysm-needle and divided. The humerus can now be rotated outwards, and the head of the bone glides forwards to its normal position.

Fairbank further recommends that if adduction is imperfect the coraco-humeral ligament be divided close to the biceps, and, if necessary, the supra-spinatus. After the operation, the arm is secured in right-angled abduction with the humerus rotated outwards, and, when the wound has healed, massage and exercises are carried out in order to prevent contraction.

Pronation of the forearm may be corrected by tendon transplanta-

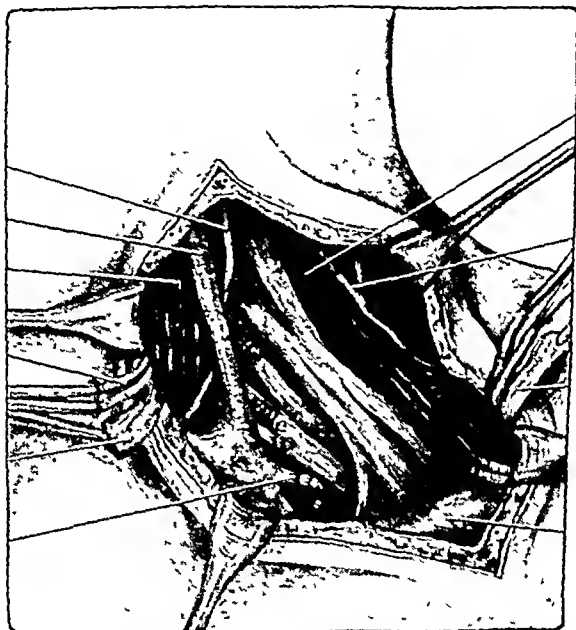


FIG 507.—Obstetrical Paralysis.

Exposure of the brachial plexus above the clavicle.

tion, as described in connection with paralytic deformities of the arm (p. 982). Persistent wrist drop may be improved in the same way.

Operative Repair of the Brachial Plexus. It is evident that if rupture of the injured cords has occurred, recovery is impossible unless a nerve suture is effected. It is recommended that if, after careful conservative treatment extending over three months, there is no evidence of returning power in the muscles, particularly in those cases in which the muscles of the forearm are involved, an exploratory operation is indicated.

Volkman-Leser Contracture

Children who have suffered from injuries of the upper extremities necessitating the application of splint or bandage, are liable, if incorrectly

CHAPTER XXXIX

SURGICAL DISEASES OF THE LOWER EXTREMITY

COXA VARA

Under normal condition the neck of the femur forms an angle with the shaft of about 130 degrees, and if for any reason this angle is diminished the condition is spoken of as *coxa vara*.

The set of the femoral neck is not directly inwards but forwards and inwards at an angle of about 12 degrees, and when a coxa vara exists this angle also is upset, for the head is either displaced backwards or, in certain exceptional conditions, forwards. Therefore a coxa vara may be said to be a combined deformity.



FIG 508—Section of the Upper Extremity of a normal Femur (Child 8 years old)
The angle of the neck with the shaft is about 130 degrees

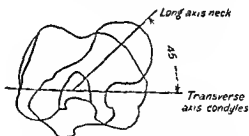


FIG 509—Everson of the Limb
The relationships of the axis of the femoral neck and of the transverse condylar axes

(a) a diminution of the vertical neck-shaft angle, and (b) an alteration of the forward neckshaft angle

ETIOLOGY Whitman has expressed the general etiological considerations so well that we may quote his words in this respect

Coxa vara of the ordinary type may be classed as one of the group of static deformities of the lower extremity caused by a disproportion between the strength of the supporting structure and the burden that is put upon it

The support may be disproportionately weak because of inherited

TREATMENT. If the case is seen within a week or two after the injury, massage and gradual stretching of the muscles may effect a great improvement. Forcible stretching under anæsthesia is unwise, as it is liable to be followed by a greater degree of contraction than was previously present.

If in an early case there is a suspicion that the peripheral nerves are involved in the pressure cicatrix, arrangements should be made to free these by open dissection. If the case comes under observation some months after the injury it may be assumed that the contracture has reached its maximum, and operative measures offer the only chance of improvement. Three operative procedures have been practised with success :—

- (1) Lengthening of the flexor tendons of the forearm (Littlewood and Davidsohn).
- (2) Shortening of the radius and ulna so as to compensate for the contraction of the muscles (Garré).
- (3) Myotomy of the muscles (Maynard-Cushing).

POST-OPERATIVE TREATMENT. Whatever the nature of the operation which has been attempted it is essential that care be taken to continue post-operative treatment for several months. This will consist in active and passive movements, massage, and faradism of the affected muscles.

SIGNS AND SYMPTOMS Because the neck is depressed the trochanter is elevated, and because the neck is twisted backwards the trochanter is thrown forwards

The distortion of the head in a downwards and backwards direction means that abduction and flexion and internal rotation movements are limited, while those of adduction, extension and external rotation are free or even increased. Particularly striking is the limitation of abduction, because it is the result of such various influences as tension on the lower part of the capsules, contact of the rim of the acetabulum with the neck, and adaptive muscular contraction.

Some degree of shortening is present in the limb, it rarely exceeds one inch, but the deformity is given an exaggerated importance by the upward tilting of the pelvis intended to compensate for the adduction.

SYMPTOMATOLOGY The first signs of the disease may date from the time when the child showed evidence of rickets or other disease associated with softening of the osseous system, the symptoms of coxa vara following immediately upon the osseous deformity, or (as is more frequently the case) a long interval of time elapsing, even into adolescence, before the coxa vara signs develop. In other cases the features of the disease begin insidiously, it may be after injury or over exertion, and this is specially noticeable in unilateral examples.

Discomfort around the hip joint in walking and awkwardness of gait are the earliest features of the disease. These are the result of the displacement of the head, and the necessary muscular readjustments. When the stability of the bone is established the subjective features subside. As shortening develops and outward rotation becomes established a limp is noticeable. There are periods when attacks of muscular spasm increase the intensity of the symptoms.

EXAMINATION shows that the limb tends to be maintained in a

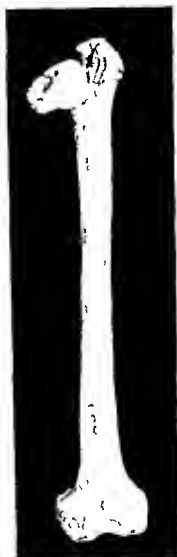


FIG 511—Coxa vara

An example of a coxa vara deformity of the left hip. The mushroom deformity of the head upon the femoral neck is well shown.

or acquired delicacy of structure or lack of resistance; it may be weakened by injury or disease, or it may be over-burdened by weight or strain. It is apparent therefore that in a general sense there is a wide possible variety of causes of coxa vara. In such conditions as osteomalacia, osteomyelitis of the neck of the femur, and arthritis of the hip joint, it is obvious that some degree of associated coxa vara will occur, but the orthopædist has urged that the generic term coxa vara should be reserved for the simple local lesion rather than for the deformity which follows a destructive lesion.'

ETIOLOGICAL PATHOLOGY. If the neck as a whole is affected by the deformity the condition is said to be one of *cervical coxa vara*; if the deformity is most marked at the epiphyseal junction it is described as an *epiphyseal coxa vara*.

Where *epiphyseal types of coxa vara* are concerned we have a considerable body of evidence that injury plays an important part in the origin of the deformity, but whether the injury causes a partial epiphyseal separation which increases under the strain of use or whether the injury increases a pre-existing distortion has not been decided. The tendency at any rate has been to classify epiphyseal coxa vara as a fracture rather than as a developmental deformity.

In *cervical coxa vara* the influence of injury is less apparent. That there may be some local bone-softening influence is possible and even likely, but in most cases the position is, as Whitman well describes it, 'a disproportion between the strength of the supporting structure and the burden which is put upon it.' One fact at least is certain—that any previous influence

which results in lessening the angle of the femoral neck, be it congenital error, rickets, local osteomalacia, or injury, acts as a predisposing factor in the development of coxa vara. A lessened angle means a greater degree of strain, and a greater degree of strain is the prelude to congestive changes within the bone, changes which end in softening and absorption of the bone lamellæ and a further degree of diminution of the cervical angle.

PATHOLOGY. Although many specimens of coxa vara have been examined, no very distinctive histological changes have been found. During the active stages of the disease the bone is congested and softened, the interior of the related joint is congested, and there is usually an effusion of fluid. In advanced cases the acetabulum is altered in so much as the upper border is less sharply defined than normal. In long-standing cases there are adaptive changes in the muscles and ligaments around the joint.

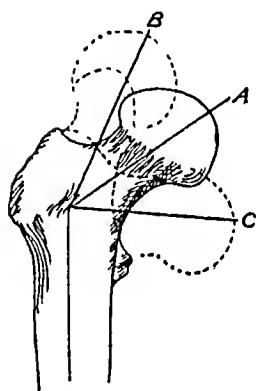


FIG 510 —The Angles of the Femoral Neck

A The normal valgus B Coxa vara C Coxa vara

common type of the disease. In bilateral examples of this type the degree of lumbar lordosis is increased.

DIAGNOSIS Tuberculosis of the hip joint and congenital dislocation are the conditions most likely to be mistaken for coxa vara. In tuberculous disease the movements of the joint are limited in every direction by reflex muscular spasm, moreover, the history is different, and X ray investigation confirms the distinction.

Congenital dislocation of the hip, particularly the anterior variety, is easily mistaken for coxa vara, but the history should prevent the mistake, for coxa vara is essentially an acquired deformity. In doubtful cases the physical and X ray examinations afford the various distinctive features.

PROGNOSIS The question of prognosis must necessarily depend upon such a variety of features as the type of the disease, the period at which active treatment is begun, and the nature of the treatment adopted. In general, it may be said that 'cervical' coxa vara is more responsive than the epiphyseal type, that the earlier the disease is treated the more favourable are the prospects, and that, if there is a prospect of improvement by conservative measures, the results are likely to be better than those obtained by the most successful operative treatment.

TREATMENT

Conservative If the deformity is discovered at an early stage, its progress may be checked by arresting the exciting causes. Standing for long periods is prevented, and work which entails muscle strain on the lower limbs is avoided. The nutrition of the part is improved by massage, exercises designed to correct the persistent adduction are prescribed, and such amusements as horse riding and tricycle riding are encouraged. Daily forcible manipulation of the limb into an abducted position may be practised. If the condition is unilateral and early in degree, a perineal crutch splint (Judson) or a convalescent hip splint may be used until such time as the part is strong enough to permit full weight bearing.

Operative In the majority of cases the deformity is so fully established that operative treatment is necessary. This may take the form of forcible abduction, of linear osteotomy or of cuneiform osteotomy.

Forcible Abduction In active cases of the disease when the bone is soft and the deformity progressive, the restoration of the normal range of abduction and internal rotation may be considered as an evidence of the correction of the deformity. It is assumed that by forcible abduction, the head is fixed by the lower part of the capsule while the deformed neck is forced against the upper border of the acetabulum, and that through the influence of these fulcra and the leverage of the limb, the deformity is overcome.

If the necessary position has been secured, the limb is fixed in a

position of slight flexion with some degree of adduction and external rotation. The muscles around the hip are wasted, the prominence of the great trochanter is increased, and this bony point is displaced upwards and forwards. The movements of abduction, extension, and external rotation are limited.

In bilateral cases the degree of limp is more marked, for the limitation of abduction necessitates swaying of the pelvis. The normal lumbar lordosis is diminished because the trochanter is displaced



FIG. 512.—Congenital Coxa vara (Child aged 3 years).

forwards. Bilateral cases are often accompanied by the deformities of knock-knee and flatfoot.

A Rare Variety of Coxa Vara.

It sometimes happens that the femoral head is displaced *downwards and forwards*, instead of downwards and backwards. In this event the clinical features are unusual, for, while abduction is limited as in the classical examples of the disease, external rotation and extension are affected in distinction to the internal rotation and flexion of the

limb is thereafter allowed to resume its normal axis, and movement is restored to the joint by massage and exercises

COXA VALGA

Coxa valga or *collum valga* is the designation given to the deformity in which the angle of the femoral head and neck with the shaft is more obtuse than normal. It is an uncommon deformity, sometimes found in association with rickets, but more commonly met with as the result of infantile paralysis affecting the hip muscles.

CLINICAL FEATURES These may be summarized as follows. The



FIG 514—Coxa valga treated by Sub trochanteric Osteotomy (Girl 10 years)

great trochanter is flattened, and its upper border may be below Nelaton's line. Adduction is limited, and the child is late in walking. When walking is attempted the gait is unsteady and swaying in character. Pain is usually absent. The leg is often abducted and rotated outwards, the gluteal muscles are atrophied. If the condition is unilateral slight scoliosis may be present. X-ray examination will confirm the diagnosis which the clinical features suggest.

TREATMENT In the majority of cases it is unnecessary to adopt any special treatment directed towards correction of the body deformity. If the child can be induced to walk and to exercise the limb, it will be found that there is a natural tendency towards correction of the error. More aggressive methods have been

plaster spica bandage in an attitude of extreme abduction and internal rotation until restoration of the parts is complete—i.e. for about six weeks. Thereafter a short plaster spica or a traction hip splint is worn for six months.

Linear Osteotomy. This operation is usually practised in cases associated with an extreme degree of outward rotation of the femur, and, as this item of deformity is not specially evident in the child, the operation of linear osteotomy is rarely indicated. If it is required it is practised at a level immediately below the trochanter minor.



FIG. 513 —Double Coxa vara (Girl 10 years).

Cuneiform Osteotomy. The usual operative remedy is a cuneiform osteotomy at a level directly opposite the lesser trochanter

The cortical substance on the inner aspect of the bone should not be divided, but retained so as to act as a hinge upon which the shaft of the femur is forced outwards until the necessary amount of abduction has been secured.

It is recommended that the size of the wedge which it is necessary to remove may be estimated with a sufficient degree of accuracy by making a paper model from an X-ray picture.

The wound is closed with catgut and the limb is immediately fixed in normal abduction with a plaster spica bandage which extends from the pelvis to the foot. Union is sufficiently firm in eight weeks, the

the origin of the disease. The general health of the child is often indifferent.

The Course of the Disease The disease may have an acute beginning or its commencement may be so insidious as to escape notice for some time.

In the acute examples an intermittent pain is complained of in the region of the hip and a moderate degree of fever may be recorded. While the pain is present muscular spasm exists, so that the hip tends



FIG. 515.—Pseudo coxalgia (Perthes' disease of the right hip) (Boy 9½ years old). The disease has undergone a spontaneous cure, but the characteristic flattening of the upper epiphysis remains.

to become flexed and adducted. These features, however, are temporary, and after a few weeks they subside, leaving some degree of stiffness in the joint.

Most cases, however, begin in a more gradual and insidious fashion. It is noticed that the child limps, particularly after walking. When questioned he may confess to some pain in the joint, but usually he describes the feature as stiffness rather than pain. The limp persists, while the pain generally disappears, though there are intervals when the pain returns and the limp is exaggerated.

recommended, but their adoption has had little success. The various methods are fixation in a position of exaggerated adduction and internal rotation, tenotomy of the abductors, and sub-trochanteric osteotomy of the femur.

PERTHES' DISEASE

Several of the older clinicians have commented on the fact that a certain proportion of cases of presumed tuberculous disease of the hip joint appeared to make an unusually good recovery, both from the point of view of time and of functional result. It is possible that many of these cases were examples of the condition now classified as pseudo-coxalgia.

It is to Legg of Boston that we owe the first distinctive description of the disease. In 1909 he described a non-tuberculous affection of the femoral head, the characteristic features of which were a flattening of the head and a broadening of the neck. Legg believed that trauma, followed by interference with the blood supply, was the origin of the change.

About the same time Sourdal of Paris, in collaboration with Calvé, presented a thesis to the University of Paris, the subject being a consideration of 250 radiograms of the hip joint. In nine instances he described a condition which would now be recognized as corresponding to pseudo-coxalgia. It was at this time also that Waldenström of Stockholm drew attention to the same peculiar condition, classifying it as tuberculous.

In 1910 Calvé analysed 500 cases of supposed tuberculous hip disease, in ten of which he described characteristic pseudo-coxalgic features, but he held that the appearances were tuberculous in their origin.

In 1910 and again in 1913 Perthes of Tübingen gave detailed descriptions of the disease, and the attention which his paper aroused was such that his name is often applied to the disease (Perthes' disease). Schwartz, an assistant of Perthes, published an elaborate account of the condition in 1914, basing his observations upon a series of twenty-two cases.

Since 1914 numerous contributions have been made to the study of the disease, and of these the recent papers of Sundt (1921) and Platt (1922) are the most suggestive and illuminating.

CLINICAL FEATURES. The majority of the cases are first recognized during the first decade of life, and more particularly from five to ten years. Legg has described the disease in a child of two and a half years and Schwartz met with a case in a girl of fifteen.

The incidence is greater in boys than in girls in a proportion of about four to one, a fact which has been explained by the suggestion that trauma (assumedly more frequent in boys) has an influence on

the origin of the disease. The general health of the child is often indifferent.

The Course of the Disease The disease may have an acute beginning or its commencement may be so insidious as to escape notice for some time.

In the acute examples an intermittent pain is complained of in the region of the hip and a moderate degree of fever may be recorded. While the pain is present muscular spasm exists, so that the hip tends



FIG. 515.—Pseudo coxalgia (Perthes' disease of the right hip) (Boy 9½ years old). The disease has undergone a spontaneous cure, but the characteristic flattening of the upper epiphysis remains.

to become flexed and adducted. These features, however, are temporary and after a few weeks they subside, leaving some degree of stiffness in the joint.

Most cases, however, begin in a more gradual and insidious fashion. It is noticed that the child limps, particularly after walking. When questioned he may confess to some pain in the joint, but usually he describes the feature as stiffness rather than pain. The limp persists, while the pain generally disappears, though there are intervals when the pain returns and the limp is exaggerated.

Under treatment the features gradually improve, and recovery, except for some limitation of abduction and internal rotation of the joint, is the rule.

PHYSICAL EXAMINATION. The general health of the child may be poor. The great trochanter is more prominent than usual; it appears to project laterally to a greater degree than its fellow, and its outline is thicker. A slight degree of elevation of the trochanter has been described in fully established examples of the disease, but we have never been able to confirm this observation. The limb as a whole may show slight muscular atrophy, but there is no trace of a localized gluteal wasting. Calvé has described the relative ease with which the head can be felt in the base of Scarpa's triangle (Calvé's Sign). The movements of flexion, abduction, and internal rotation are slightly limited. Spasm and acquired shortening of the adductors, and deformity of the femoral head explain the interference with movement.

RADIOGRAPHIC SIGNS. The X-ray appearances of the head and neck of the femur are characteristic. The earliest change is a flattening of the rounded upper surface of the head; some time later the central nucleus increases in density, probably because of hyper-calcification, and afterwards it affords a curious 'fragmented' appearance. Thereafter the head undergoes a further distortion until it may exist as a flattened plate of tissue.

The neck becomes shortened and broadened in outline, the upper portion may show a fragmented appearance similar to that displayed in the head, the epiphyseal cartilage may also become distorted in outline.

Changes may appear in the acetabulum—the outline of the cavity alters in conformity with the changes in the head, and a parallel condition of fragmentation may be detected in the upper portions of the acetabular wall. A change which is often noticeable is the appearance of increased depth between the femoral head and the floor of the acetabulum.

In certain old-standing cases arthritic changes may appear in the joint.

ETIOLOGY. There is considerable doubt regarding the method of production of the disease.

Trauma. Many observers have inclined to the view that trauma is the responsible feature in so far as it interferes with the blood supply and so inaugurates a nutritional disorder of the head which results in atrophy; the changes in the neck are considered to be due to a compensatory hyperemia. The difficulties in accepting the traumatic theory are that a certain proportion of cases are bilateral, and that in many there is no history of injury.

Rickets. Calvé originally put forward the suggestion that rickets might prove to be the responsible factor, but the author of the theory has now abandoned it, and we have no evidence that the changes are in any way rachitic.

Syphilis Roberts of New York described the condition as one of syphilitic osteo chondritis, but no one seriously accepts this view. Roberts' cases may have been examples of a comedone.

Abnormal Ossification Weil and Dehtaly believed that the disease was a developmental one, and that a delay in the formation of the epiphyseal nucleus affected the growth and the nutrition of the related head. We have no evidence that the possibility ever arises.

In this class may be included the views of certain writers that errors in the secretion of the ductless glands, particularly the thyroid,



FIG. 516.—Pseudo coxalgia (Perthes disease) (Boy 10 years old)

An example of the disease affecting the left hip. There is marked deformity of the upper epiphysis. Disease of 3 years' duration.

are responsible for the imperfect development of the nucleus, and the endosteum of the head.

Infection The view which at present meets with most acceptance is that an attenuated infection, probably with a staphylococcus aureus is the cause of the disease. Certain facts in the clinical history suggest this origin, particularly the occasional occurrence of fever and the general ill health. Several observers have succeeded in isolating a staphylococcal organism, and Plumister has described the histology of the structure of the epiphysis as suggestive of an infective lesion.

If the infective theory is the correct one, the similarity between pseudo-coxalgia, tarsal scaphoiditis and the Osgood-Schlatters disease is striking

DIAGNOSIS. As a rule the X-ray appearance is so characteristic that the true nature of the disease is recognized. When confusion arises it is in the early stages before the typical radiological changes are apparent.

The features of limping, stiffness, and pain may suggest an extra-articular tuberculous lesion in the neighbourhood of the hip joint, and, in fact, without the aid of an X-ray examination, a distinction between the two conditions may be a matter of the greatest difficulty.

Coxa vara closely simulates pseudo-coxalgia as far as the clinical features are concerned, but the X-ray appearances remove any difficulty of distinction.

PROGNOSIS. The prognosis aspects of the disease are favourable. Even if no special treatment is followed, the condition becomes arrested, the fragmentation of the epiphysis disappears, the bone texture is restored on a somewhat denser plan, and the epiphysis regains a rounded outline. In the majority of cases there is no apparent disability of function after the cure of the local condition has been completed.

The duration of the disease varies within wide limits, but on an average a period of two years elapses before symptoms and signs disappear.

TREATMENT. It is generally accepted that immobilization of the part for a period of six months or one year, followed by an interval in which weight-bearing is prohibited, should be the routine of treatment, but in this connection Sundt's ¹ findings are interesting. In three groups of cases divided as follows—

- (1) 19 cases in which the joint was immobilized for two years,
- (2) 10 cases in which the joint was immobilized for one year,
- (3) 23 cases which were allowed complete freedom—

he found that there was eventually no real difference in the degree of deformity.

Yet, in spite of such negative findings, the consensus of opinion is that in the early stages of the disease it is well to immobilize the joint for six or twelve months in a light plaster case, the limb being maintained in an abducted position. For a further period of six months a hip splint of the Thomas or of the traction pattern with patten and crutches should be used.

CONGENITAL DISLOCATION OF THE HIP

The error of congenital dislocation or displacement of the hip joint is a condition of great importance from the point of view of the child's future activity and usefulness.

¹ Sundt, H.: *Zentralbl. f. Chir.*, May 29, 1920.

ETIOLOGY

The way in which the displacement arises has not yet been satisfactorily demonstrated. It may be said that opinion is divided into two schools

- (1) That the error is the result of a developmental defect,
- (2) That the dislocation results from mechanical causes acting on structures originally normal

Certain arguments are advanced in favour of the *mechanical theory*



FIG 517 —Congenital Dislocation of the right Hip

It is claimed that the condition is unknown in the lower animals that it is in fact one of the prices paid by mankind for the orthograde position. It is pointed out that when the dislocation is reduced the development of the parts improves, and the sex incidence (86 per cent in females) is quoted in proof of the same view.

The main argument in support of the *developmental theory* is the recognition of the fact that congenital dislocation of the hip is common in monsters where there are many associated errors. Probably Le Damany is correct when he claims that a pure developmental etiology should be reserved for this class (teratological dislocation) where there is a deficiency in the hip forming tissue of the *anlage*.

If the infective theory is the correct one, the similarity between pseudo-coxalgia, tarsal scaphoiditis and the Osgood-Schlatters disease is striking.

DIAGNOSIS. As a rule the X-ray appearance is so characteristic that the true nature of the disease is recognized. When confusion arises it is in the early stages before the typical radiological changes are apparent.

The features of limping, stiffness, and pain may suggest an extra-articular tuberculous lesion in the neighbourhood of the hip joint, and, in fact, without the aid of an X-ray examination, a distinction between the two conditions may be a matter of the greatest difficulty.

Coxa vara closely simulates pseudo-coxalgia as far as the clinical features are concerned, but the X-ray appearances remove any difficulty of distinction.

PROGNOSIS. The prognosis aspects of the disease are favourable. Even if no special treatment is followed, the condition becomes arrested, the fragmentation of the epiphysis disappears, the bone texture is restored on a somewhat denser plan, and the epiphysis regains a rounded outline. In the majority of cases there is no apparent disability of function after the cure of the local condition has been completed.

The duration of the disease varies within wide limits, but on an average a period of two years elapses before symptoms and signs disappear.

TREATMENT. It is generally accepted that immobilization of the part for a period of six months or one year, followed by an interval in which weight-bearing is prohibited, should be the routine of treatment, but in this connection Sundt's ¹ findings are interesting. In three groups of cases divided as follows—

- (1) 19 cases in which the joint was immobilized for two years,
- (2) 10 cases in which the joint was immobilized for one year,
- (3) 23 cases which were allowed complete freedom—

he found that there was eventually no real difference in the degree of deformity.

Yet, in spite of such negative findings, the consensus of opinion is that in the early stages of the disease it is well to immobilize the joint for six or twelve months in a light plaster case, the limb being maintained in an abducted position. For a further period of six months a hip splint of the Thomas or of the traction pattern with patten and crutches should be used.

CONGENITAL DISLOCATION OF THE HIP

The error of congenital dislocation or displacement of the hip joint is a condition of great importance from the point of view of the child's future activity and usefulness.

¹ Sundt, H. : *Zentralbl. f. Chir.*, May 29, 1920.

child's limb at birth is possibly the procedure which produces the displacement. This manoeuvre of immediate forcible extension is a practice in certain localities, and it may explain the curious local incidence which the disease sometimes appears to have.

Other Theories of Causation Various other theories of causation have been put forward, of which only the briefest mention need be made. Intra uterine traumatism has been blamed, but no evidence in support of this exists. Trauma during birth has been held responsible, and, in conjunction with the errors we have described, its influence may well be important. Muscular contraction, the result of central nervous disease, and paralysis due to anterior poliomyelitis have been suggested as causative factors, but no evidence of either condition exists in the typical case.

Incidence of Sex and Side The occurrence is commoner in females than in males in a proportion of 6 to 1. The special configuration of the pelvis in the female is the explanation of the unequal division.

About 75 per cent of the cases are unilateral, the remainder bilateral. The left side is more commonly affected than the right, but the difference in this respect is not great.

PATHOLOGY

It must be appreciated that the pathological changes vary according to

the age of the patient, the morbid anatomy of an untreated congenital dislocation of a child of twelve years being very different from that of a newly born child. In the former the secondary changes, the result of unequal pressure and incorrect position have produced altered configurations which are not present in the original deformity. The following details apply to the early untreated examples of the disease, the changes being grouped on an anatomical basis.

Changes in the Pelvic Bone The entire pelvic bone on the side of the dislocation is imperfectly developed, and there may be an imperfect ossification of the conjoined rami of pubis and ischium. The acetabulum is triangular in outline and shallow in depth, but rarely



FIG 519—Congenital Dislocation of the Hip Joint (After Adams)

To show the hourglass contraction of the capsular ligament

We believe that, excluding the variety where gross errors of development are at fault, congenital dislocation of the hip has an origin which is partly developmental and partly mechanical. If the outline of the acetabulum is studied in a typical case it will be found that the acetabular rim is deficient in its upper and posterior margins, while examination of the upper end of the femur shows that there is an anterior torsion of the head and neck on the shaft. The torsion is the essential factor in the production of the deformity. Because of it the femoral head has never been accurately in position in the acetabulum, with the result that there is insufficient excavation of the



FIG. 518 —A Sub-luxable Hip (*Le Damany*) (Child 2 years old).

The upper shelf of the acetabulum is imperfectly formed, and the head of the bone tends to be displaced upwards and backwards.

cavity, and an imperfect postero-superior margin, and in the absence of this upper margin dislocation of the head is likely to occur. If this view is correct, the actual stage of dislocation is probably post-natal in its occurrence. It may be possible to recognize the existence of the deformity before the displacement has occurred by the unusual degree of vertical movement in the hip joint. To this condition of affairs *Le Damany* has applied the term of the '*subluxable hip*.'

With a hip in such a subluxable condition forcible extension of the

marized by saying that the pelvi femoral group muscles are shortened, while the pelvi trochanteric muscles are stretched and lengthened

Changes in the Ligaments The capsular ligament is stretched, and a circular narrowing, corresponding to the line of the ilio psoas muscle, may produce an hour glass contraction. The ligamentum teres is thin and flattened, sometimes it is absent. It is usual to find an excess of fluid within the capsule of the joint and the cotyloid ligament is imperfect in its formation.

The Position which the Head may occupy A displacement of the head upwards and backwards is the usual event, a subspinous position is present in about 2 per cent of cases, a forward or pelvic displacement is equally rare.

Later Changes As age advances a series of changes occurs which result from altered function and from decreased blood supply through the atrophied ligamentum teres. These changes affect the femoral head, they result in deformity of the upper epiphysis, and even in complete absorption of the head and neck. It is important to realize that the changes may continue after a successful reduction of the dislocation.

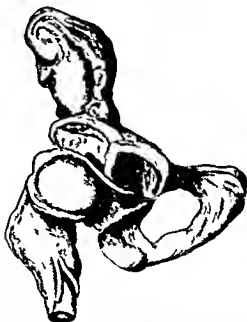


FIG 521 —Congenital Dislocation of the Hip Joint (After Lorenz)

A well formed false acetabulum lies above the proper cavity and the femoral head is in a coxa vara attitude to the shaft.

THE CLINICAL HISTORY

It is unusual for the deformity to be discovered at birth. An observant examiner may notice an unusual prominence on the dorsum ili, or an abnormal mobility of the hip in one direction, but as a rule the deformity is undetected until the child begins to walk. A limp is then noticed, and, as greater freedom in walking is practised, the limp becomes more noticeable. Expert advice is now sought, and the condition is recognized and treated.

It is of interest to notice the eventual history of cases which have been untreated, or in which attempts at reduction have failed. The functional disability rapidly increases between the ages of twenty and

obliterated; above it, in a varying position, is the depression of the false acetabulum in which the femoral head rests. Between the false and the true acetabula there is a deficiency of that postero-superior rim upon which the stability of the cavity so much depends.

Changes in the Femur. The head of the femur is large in comparison with the existing acetabulum; the normal ratio between the two is therefore reversed. On the posterior and inferior aspects of the head there is flattening of the rounded outline. Owing to the small size of the centre, the upper epiphysis is imperfectly ossified, so that there is a conical deformity of the head or even a complete disappearance of the upper epiphysis.

The neck of the femur is usually shortened, and its relationship

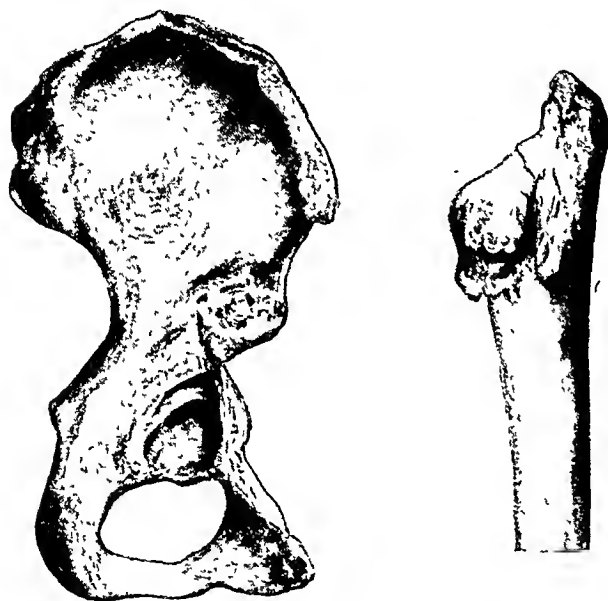


FIG. 520.—Congenital Dislocation of Hip.
(After Adams.)

Specimen obtained from long-standing unreduced dislocation of the hip. A false acetabulum has developed above the original and the head and neck of the femur have disappeared

to the shaft is generally in a position of coxa vara—a coxa valga is an uncommon. The most important change in the neck, however, is exaggeration of the normal degree of anteversion—while 12 degrees is the usual angle, in congenital dislocation it varies from 30 degrees to 75 degrees or even 90 degrees. The shaft of the bone is thinner and shorter than that of the opposite side, and the upper half shows the outward rotation to which allusion has been made.

Changes in the Muscles. In describing the muscular changes it is convenient to group the muscles into two divisions: (1) the *longitudinal* or *pelvi-femoral group*, in which the muscles pass in the long axis of the limb, the upper attachment being to the pelvis and the lower to the limb below the level of the hip joint (to this group belong such muscles as the adductors and the hamstrings); and (2) the *transverse* or *pelvi-trochanteric group*, in which the muscles pass across the long axis of the limb from their origin on the pelvis to their insertion in the neighbourhood of the trochanter, e.g. the gemelli, the obturators, and the gluteal muscles. Recognizing two such groups, the muscular changes may be sum-

now focussed on the region of the hip. In anterior view reveals asymmetry of the groove between labium and thigh, a hollowing of the front of the thigh below the centre of the inguinal ligament, and in bilateral cases a distinctive broadening of the perineum. A lateral view may show an elevation of the trochanter as compared with the opposite side. Posteriorly, the buttock fold is less distinct on the affected side, and in posterior dislocations the displaced head gives rise to a prominence on the dorsum ilii.

Palpation Palpation confirms much of what inspection has shown, and it reveals certain additional facts.

On placing the finger lightly below the centre of the groin where the already mentioned hollow exists it is appreciated that it is difficult to feel the pulsation of the femoral vessels. This is due to the absence of support of the femoral neck, and the feature is spoken of as the *vascular test*. Deeper palpation in this region appreciates the absence of the femoral head and neck from their usual position. On the outer side of the joint, the elevation of the trochanter may be demonstrated, and posteriorly it may be possible to make out the outline of the displaced head.

Movements With certain exceptions the movements at the hip are free, and can be carried out without pain or discomfort. It is usual to find limitation of abduction and of external rotation, in a small proportion of cases internal rotation is also limited. The interference with the movements is to be explained by the shortening of the adductor group of muscles, and the mechanical obstruction offered by the displaced head and neck of the femur. In early untreated cases it is possible to produce a telescopic movement at the hip joint, but in later cases this sign disappears.

Measurements The ilio malleolar measurement shows shortening in comparison with the healthy limb. Even in double dislocation there may be an asymmetry in length between the two sides. The



FIG. 523.—Double Congenital Dislocation of Hip Joint (Girl 10 years)

The lumbar lordosis and the prominence caused by the displaced heads are well shown.

thirty years ; of cases over thirty years of age there are very few who are able to walk one mile, and a considerable proportion are confined to house or even to bed.

THE CLINICAL EXAMINATION AND THE PHYSICAL SIGNS

Inspection. It is probable that the child walks into the presence of the examiner, and the limp is therefore the first clinical feature to



FIG. 522.—Double congenital Dislocation of Hip Joint.

be observed. It is of a sinking type, the body on the affected side being perceptibly lowered as weight is borne by the dislocated limb. In double dislocation there is a waddling or rolling gait (the sailor gait).

When the child is stripped it may be noticed that the figure outline is altered by the presence of a lumbar lordosis. If the child is young, the deformity is an indication of a double dislocation, but in older children a unilateral dislocation may give rise to a similar appearance. Inspection of the lower limbs reveals a lack of development on the affected side—the thigh is thinner, the buttock flatter, and the limb may show a shortening as compared with its fellow. Inspection is

parallel to the plane of the floor, because the transverse or pelvi-trochanteric group of muscles contract and fix the lateral wall of the pelvis against the head of the femur. If, however, the limb upon which the child stands is the subject of a congenital dislocation of the hip the transverse group of muscles is under a double disadvantage—not only are they stretched and weakened, but the existence of the dis-

location robs them of a proper fixed point. The result is that when the child stands upon the dislocated limb, the pelvis, instead of being maintained parallel to the ground, sinks downwards on the unsupported side. The demonstration of this feature is known as Trendelenberg's sign, and it is of value in differential diagnosis.

Narath's Sign If the hip is the situation of a congenital dislocation the psoas tendon is displaced outwards as it crosses the pelvic brim, leaving a weak area beneath the inner half of Poupart's ligament. In many cases it is possible to demonstrate the gap which results by inserting the tips of the fingers into it, and a hernia may appear at this point.



FIG 52a—Trendelenberg's Test applied to a child suffering from congenital Dislocation of the left Hip

Observe the depression of the right buttock fold when weight is borne by the affected leg

X-Ray Examination

The examination is completed by X-ray investigation. In addition to demonstrating the existence of the dislocation the examination should give information on three points—the outline of the femoral head, the depth and outline of the acetabulum and the degree of anteversion which is present in the femoral neck. This last detail is of considerable importance, and the feature is best investigated by taking two plates, one with the patella pointing straight forwards, and a second with

older the child the greater is the degree of shortening, and on an average it varies from $\frac{1}{2}$ inch to 2 inches. It is important to notice that the shortening is variable in degree, being diminished by extension and increased by weight-bearing. When the shortening is analysed it is found to exist above the level of the trochanter; in other words, it is due to displacement upwards of the femoral head.

The various measurements which are employed to demonstrate up-



FIG. 524.—Congenital Dislocation of the Hips.

Double congenital dislocation of the hip joints in child 8½ years old. The prominences caused by the displaced femoral heads and the lordosis which accompanies the bilateral dislocation are well shown.

ward displacement of the trochanter (Nelaton's line, Bryant's triangle and Chiene's lines) confirm the disposition of the shortening. It should be noted, however, that in long-standing cases there is some interference with the growth in length of the femur, and this will exaggerate the shortening.

In unilateral cases the umbilico-malleolar measurement generally shows some degree of apparent shortening owing to the persistent adduction of the displaced limb.

Special Features. *Trendelenberg's Test.* When a normal individual stands on one leg the transverse pelvic line is maintained

dislocation may ensue. The case history and the ease with which replacement is possible distinguish the condition from other types of dislocation.

III Coxa vara. Without the aid of an X-ray this condition is very liable to be confused with congenital dislocation. The distinguishing features of coxa vara are—the limp is less severe, the shortening is constant (not variable as in congenital dislocation), on rotation of the limb it may be possible to feel the head in its normal position, and Trendelenberg's sign is reversed, the unsupported side of the pelvis being tilted upwards. There are many cases, however, in which the similarity is so great that only an X-ray will make the distinction clear.

PROGNOSIS

In the untreated case, the deformity, lameness, and shortening increase rapidly during the years of growth. The tendency is for the displaced head to continue to migrate until it is arrested by the tension of the thickened capsule and the stretched muscles, actual neoarthrosis is a rare occurrence. In bilateral cases the progress of the deformity is apt to be rapid, and joint pain and muscular spasm may become so marked as to lead to virtual invalidism. Even where the dislocation has been reduced the eventual outlook is unsatisfactory, for arthritic changes may ensue which lead to absorption of the head and neck with subsequent recurrence of the dislocation. The lesson, however, which a study of the prognosis teaches is that every effort should be made to reduce the dislocation.

TREATMENT

The consideration of treatment resolves itself into two headings

- I Treatment by manipulation, and
- II Treatment by open operation

I TREATMENT BY MANIPULATION

The most suitable Age. Provided that the child is old enough to have control over the organic reflexes, treatment may be begun as soon as the diagnosis is made, but the analysis of a large series of cases has shown that during the third year is the ideal time to begin manipulative treatment. After the third year successful manipulation becomes gradually more difficult with each year, until by the eighth year the probability of successful manipulative reduction is remote.

Preliminaries to the Reduction. As the manipulation is carried out under anaesthesia the usual preparations are made. Attention should be paid to the condition of the bowel, as a flatulent distention may interfere with the proper application of plaster. It has been recommended that preliminary extension of the limb makes reduction easier, but we have not found the recommendation of real practical value.

the patella pointing inwards as far as it is possible to invert the limb. If an abnormal degree of anteversion is present, the first plate will show the femoral head as though it were superimposed on the trochanter, while the second will demonstrate the outline of the head and neck distinct from the trochanter. If estimation is made by a goniometer of the degree of inversion of the limb which is necessary to afford a complete outline of the head and neck, the figure obtained gives a fair estimate of the degree of anteversion which exists. The estimation is valuable when treatment is carried out.

DIAGNOSIS

The history of a painless sinking limp, first noticeable when the child begins to walk, should suggest the likelihood of a congenital dislocation. The confirmatory clinical features are the shortening of the limb, the displacement upwards of the trochanter, the absence of the head from its normal position below the centre of Poupert's ligament, the limitations of abduction and internal rotation, other movements being free, and in certain cases the demonstration of the head on the dorsum of the ilium. A positive Trendelenberg's sign is a further point in evidence, and the diagnosis is confirmed by X-ray examination.

Differential Diagnosis

Certain conditions resemble congenital dislocation of the hip joint.

I. Post-infective Dislocation. A child may show the clinical features of a dislocated hip, the history being that the signs became noticeable soon after the child began to walk, X-ray examination demonstrates a dislocation, yet it may not be a congenital displacement.

Infants who have suffered from scarlet fever or from one of the exanthemata may develop an acute arthritis of the hip joint, and in the presence of more urgent symptoms the hip condition is overlooked, the joint capsule ruptures, and the head of the bone becomes dislocated. A superficial abscess may appear, and be treated, and the condition is forgotten until the child begins to walk. It is of great importance to recognize the existence of such cases, for, if the condition described is treated on the assumption that it is a congenital error, disaster will certainly ensue.

Post-infective dislocation should be suspected—

- (1) When there is a history of previous infection in the region of the hip.
- (2) When the hip movements are more limited than those of a congenital dislocation.
- (3) When X-ray examination shows greater deformity and absorption of the head than is usual in a congenital dislocation.

II. Post-paralytic Dislocation. In cases of extensive infantile paralysis involving the muscles around the hip joint a secondary



FIG 526b—Stretching the Hamstring Muscles



FIG 526c—Stretching the Adductor Group of Muscles

B Stretching the Ligaments and bringing the Head of the Femur into the lowest possible position The child lying on its back with the hip bent to a right angle, the ligaments around the hip

The Technique of Reduction

A. Stretching the related Parts. The child is placed on a low table and deep anæsthesia is induced. The procedure begins with a thorough stretching of the various structures around the hip joint which may interfere with reduction.

(1) *The Hamstrings.* The child lying supine, and the opposite thigh being flat on the table, the assistant holds the limb firmly in this position so as to control the pelvis. The surgeon now flexes the affected hip joint to its full extent, and, while it is in this position the knee is gradually straightened. The manipulation is carried out slowly and carefully, and kneading of the muscles over the ischial tuberosity may



FIG. 526A.—Reduction of Congenital Dislocation of the Hip by Manipulation. Method of fixing the Pelvis by holding the Limb of the healthy side against the table.

In this way the assistant does not interfere with the manipulation

assist the process. The manipulation is continued until the knee is completely extended while the hip is in full flexion.

(2) *The Adductors.* The child remaining in the supine position, the limb is now gradually abducted. At first the shortened adductors present considerable resistance, but by careful manipulation this is overcome. It is unwise to break or to divide the adductors, as they constitute valuable 'stays' for keeping the hip in position after reduction has been carried out: stretching is all that is necessary.

(3) *The Ilio-psoas and Anterior Muscles.* The child is now placed on its face, and, while the assistant fixes the pelvis, the surgeon gradually hyper-extends the limb at the hip joint. The risk of fracturing the upper end of the femur makes this manœuvre a dangerous one, but the risk is avoided if the hand and forearm are placed along the anterior aspect of the thigh so as to support the whole length of the femur.

pulled downwards to its fullest extent. After these preliminaries the actual manipulation of reduction is proceeded with.

C The actual Reduction If the displaced head lies immediately above the acetabulum, and if the child is young, simple extension may produce reduction. A result so easily achieved is, however, unusual, and a more complicated manoeuvre of reduction is generally required. The child lying supine, the affected limb is grasped at the knee, hip and knee being fully flexed. The other hand, clenched, is placed behind the hip in such a position that the radial edge of the hand is resting against the posterior edge of the trochanter. While the hip is fully flexed the surgeon forces the head



FIG. 526r.—Bringing the Head down

of the femur downwards and backwards by exerting force in the long axis of the femur the pelvis being fixed by the assistant placing his hands on the anterior superior spines of the ilium. The limb is now abducted and rotated outwards and while this movement is being carried out the trochanter is guided forwards by the free edge of the hand upon which it rests. As the abduction and rotation outwards begin to approach a right angle to the lateral line of the body, a sense of resistance is felt as the displaced head comes into contact with the posterior edge of the acetabulum. It is at this point that care is chiefly required. If it is attempted to overcome the obstruction blindly the upper end of the femur may break, but with care and gradual manipulation in a favourable case the head slips

SURGERY OF CHILDHOOD

are now stretched. In this position, with the hip and knee flexed to right angles, the assistant secures the pelvis by placing a hand on each



FIG. 526D.—Stretching the Ilio-psoas



FIG. 526E.—The manœuvre of bringing the Head of the Femur forwards. Observe how the forearm is hooked around the child's knee.

iliac crest, the surgeon, facing the patient's head, hooks his arms round the leg below the knee, and exerts strong upward traction.

The limb is now fully extended, and, with a broad towel in the perineum to afford a counter-pull, the foot is grasped and the limb is

pulled downwards to its fullest extent. After these preliminaries the actual manipulation of reduction is proceeded with.

C The actual Reduction If the displaced head lies immediately above the acetabulum, and if the child is young, simple extension may produce reduction. A result so easily achieved is, however, unusual, and a more complicated manoeuvre of reduction is generally required. The child lying supine, the affected limb is grasped at the knee, hip and knee being fully flexed. The other hand, clenched, is placed behind the hip in such a position that the radial edge of the hand is resting against the posterior edge of the trochanter. While the hip is fully flexed the surgeon forces the head



FIG. 526F.—Bringing the Head down

of the femur downwards and backwards by exerting force in the long axis of the femur the pelvis being fixed by the assistant placing his hands on the anterior superior spines of the ilium. The limb is now abducted and rotated outwards, and while this movement is being carried out the trochanter is guided forwards by the free edge of the hand upon which it rests. As the abduction and rotation outwards begin to approach a right angle to the lateral line of the body a sense of resistance is felt as the displaced head comes into contact with the posterior edge of the acetabulum. It is at this point that care is chiefly required. If it is attempted to overcome the obstruction blindly the upper end of the femur may break, but with care and gradual manipulation in a favourable case the head slips



FIG. 526G.—The first stage of the actual Reduction.

The thigh is acutely flexed, the surgeon's left arm is forcing the femur downwards and backwards in the long axis of the bone, while the surgeon's right hand is lifting the trochanter forwards.



FIG. 526H.—The second stage of Reduction.

The abduction and rotation outwards is beginning.

into the acetabulum with a perceptible jerk, and sometimes with an audible crack.

Modifications of the Manœuvre of Reduction. (1) *Reduction in the prone Position.* This method may succeed where the

ordinary method fails. With the child lying on its back, the limb is abducted and rotated outwards to a right angle with the body, the knee being flexed. In this position one hand grasps the knee while the other is placed over the posterior edge of the trochanter and the displaced head. By a careful circumduction movement of the knee, lifting the knee off the table while the other hand exerts downwards and forwards pressure on the head and trochanter, it is often possible to guide the head into place.

(2) *Modification if there is much Intorsion of the Neck* Hibbs has recommended that if there is a considerable degree of antetorsion it may be advisable to carry out a preliminary osteotomy in the lower third of the femur before reducing the dislocation. He advises that after the bone is divided the lower fragment should be rotated outwards and allowed to unite in this position. The patient should then use the limb for two months, and during this time the eversion and therefore the antetorsion of the neck is further improved by exercises and splints. When the antetorsion has been corrected reduction is carried out.

Apart, however, from this recommendation (which, of course, will only be followed in the most extreme cases), if the X ray examination shows a moderate degree of antetorsion, the ordinary manoeuvre of reduction must be modified. The modification is that abduction and eversion must not be carried to the extent which is advised in the ordinary case, instead of the limb being abducted and everted to a right angle, reduction is attempted with the limb in a medium position.

To recognize that the Dislocation is reduced. There is usually no difficulty in recognizing that the reduction is complete—a characteristic feature is the stability of the limb in the abducted everted position, and this stability is increased if the adductors and hamstrings have been kept intact. These muscles act as stays, holding the shaft of the femur against the lateral wall of the pelvis, and the test is often quoted that, owing to the tension of the hamstrings there is inability to extend the knee while the hip is in the reduced position.

Reasons for Failure of Reduction In certain cases attempts to reduce the dislocation fail. It may be that the head passes into the acetabulum only to escape from it at once. This is an unpromising situation, as it means an imperfect acetabulum or a misshapen head. On the other hand, it may be that the resistance to reduction is so strong that there is a risk of breaking the femur. This difficulty is a hopeful one for, by further stretching, it is likely that reduction will succeed, and having been secured, relapse is unusual, the situation often arises with a deep acetabulum and a well formed head. Hour glass contraction of the capsule is the most serious obstacle to reduction. Its presence may be recognized by the manipulation which seems just on the point of succeeding and then fails with a characteristic slipping sensation.

What is to be done in the event of Failure? Repeated attempts should be made before defeat is acknowledged. If a shallow acetabulum or an imperfect head is the fault the manœuvre of reduction should be gone through, and when the head has been brought into contact with the imperfect acetabulum, it should be kept there by means of a plaster case. It is possible that the presence of the head may deepen the acetabulum and thus improve the future outlook.

If an hourglass contraction of the capsule is present an open operation will almost certainly be necessary to secure reduction, and it should not be postponed too long



FIG. 526J.—The Reduction completed.

Note the inability to extend the knee.

The After-treatment. When reduction has been carried out steps are taken to prevent a recurrence of the dislocation until such time as the parts become adapted to the changed position, and the acetabulum is sufficiently deepened to hold the head securely; the limb is therefore encased in plaster of Paris. The plaster extends from the nipple to below the iliac crests, and on the affected limb it includes the knee. The inclusion of the knee in the first plaster is important, as it prevents rotation, and thus movement, if uncontrolled, might result in the re-dislocation of an unstable case. The plaster should be accurately moulded around the various bony points, yet without causing undue pressure. We make it a practice to insert a round firm pad over the posterior aspect of the reduced head, and this is incorporated with the plaster; we have found that this addition holds the head in good position. When the

plaster is hard an X ray is taken to confirm the reduction, the bones being easily visible through the plaster

This plaster is kept in place for three months. During this period the child is encouraged to try to walk if he desires to do so, and for this purpose a boot and a high patten are provided. Walking exercise improves the muscles and deepens the acetabulum, while it does not increase the risk of displacement.

At the end of three months the plaster is removed and another X ray is taken. We believe that, if the X ray shows the head in position in a deep acetabulum, it is unnecessary to repeat the plaster. If, however, there is any suspicion of instability, further plaster treatment is required. Under anaesthesia the limb is brought down from its right angled position through half a right angle, and care is taken to ensure that some degree of internal rotation of the limb is carried out. In this position the second plaster is applied. It need not extend so high around the body, it may stop above the knee, and the posterior pad is unnecessary.

The second casting is kept in place for three months, and another X ray is taken. It may now be considered safe to abandon the plaster, but if any doubt remains, a third cast is applied after the limb has been brought down into an abducted position with the external rotation corrected.



FIG 526K.—Plaster applied with limb in frog position

At whatever stage the application of plaster may cease, much care and patience are required in the subsequent after treatment if a good result is to be obtained. Daily massage and exercise are required, and the child should be encouraged to walk, at first with a walking machine, and later without support. At night it is useful to arrange for the child to sleep in some type of splint, such as a double Hamilton, which will keep the limb in the correct position. If there is much tendency for the limb to become displaced into a position of flexion and abduction, the child is fastened on a frame resembling an Abbot's frame, upon which, by means of bands and ratchets, a corrective pull is maintained.

Such is an outline of the scheme of after treatment which we recommend and use, but there is considerable diversity among surgeons

in this matter. It is of interest to record a summary of other methods. Some surgeons recommend that the thigh should be kept in full abduction for one year, for by so doing they claim that the head is kept in contact with the acetabulum. Blanchard advises continuous abduction for eight months. Redard claims that immobilization should not last longer than six months. Calot insists on the head and neck of the femur being kept horizontal and transverse throughout



FIG. 527.—Congenital Dislocation of the Hips.

Manipulative reduction of a double dislocation has been completed, and the legs have been gradually brought down to the proper axis. The photographs illustrate the unusual width of the perineal space and the overversion of the limbs, sometimes a peculiarly difficult obstacle to overcome.

the entire treatment; he corrects the errors of torsion and of *coxa vara* by internal rotation and by abduction. Lamay Evans emphasizes the necessity of keeping the head and neck of the femur concentrically in the acetabulum, and he encourages early function; Churchman applies the plaster in a position of abduction from the waist to the knee, and the child is encouraged to walk.

Risks attending Reduction. The risks which attend reduction are: fracture of the upper end of the femur or of the neck, the

production of a hæmatoma, and injury to nerves or blood-vessels

Fracture is the most frequent risk—the upper end of the shaft breaks during manipulation, or the neck is injured during the reduction. If the accident occurs manipulation should cease, and the fracture is treated on the ordinary lines. A former fracture is not necessarily a bar to future attempts at reduction.

The production of a hæmatoma is less common since tenotomy has been abandoned. If a large hæmatoma develops, it should not be incised, it is better to delay until the effusion becomes fluid, and then to aspirate it.

Injury to the larger blood vessels may occur in forcible manipulation in older children, and the accident calls for immediate local attention. Injuries to the sciatic, obturator, and femoral nerves have been recorded, but such occurrences are rare.

OPERATIVE TREATMENT

Indications If previous manipulative attempts have failed, in a child over five years of age, careful consideration should be given to the possibility of operative treatment. Two provisions are important.

- (1) The open operation must not be done immediately after a manipulative attempt—at least three weeks should elapse.
- (2) In cases of double dislocation the operation must not be performed on both sides because of the risk of subsequent ankylosis.

Types of Operation Two types of open operation have come to be recognized, and they are associated with the names of surgeons who first practised them.

A *Hoffa Lorenz*—in which an attempt is made to improve and deepen the acetabulum.

B *The Burghard operation*—in which the bones are untouched.

Various modifications of these operations have been planned, as, for example, by Albee and by Fairbank, who attempt to deepen and strengthen the acetabulum by a bone graft.

In most cases the operative procedure will entail certain important steps—free exposure of the capsule, division of the ilio-psoas tendon, division of the contraction of the capsule, if such exists, deepening of the acetabulum, if it is too shallow, and accurate reposition of the displaced head. The route of access is largely a matter of choice, and frequently it has to be modified in individual cases. The following is an account of a typical operation, as we have performed it.

Operation The child is placed supine with a sand pillow beneath the pelvis, the affected limb is sterilized and wrapped in a towel, so as to be free for any subsequent manipulation.

The incision begins 1 inch below the iliac crest $2\frac{1}{2}$ to 3 inches from the anterior superior spine, and curves downwards and slightly forwards for 4 inches. On deepening the incision the

in this matter. It is of interest to record a summary of other methods. Some surgeons recommend that the thigh should be kept in full abduction for one year, for by so doing they claim that the head is kept in contact with the acetabulum. Blanchard advises continuous abduction for eight months. Redard claims that immobilization should not last longer than six months. Calot insists on the head and neck of the femur being kept horizontal and transverse throughout



FIG. 527.—Congenital Dislocation of the Hips.

Manipulative reduction of a double dislocation has been completed, and the legs have been gradually brought down to the proper axis. The photographs illustrate the unusual width of the perineal space and the eversion of the limbs, sometimes a peculiarly difficult obstacle to overcome.

the entire treatment; he corrects the errors of torsion and of *coxa vara* by internal rotation and by abduction. Lamay Evans emphasizes the necessity of keeping the head and neck of the femur concentrically in the acetabulum, and he encourages early function; Churchman applies the plaster in a position of abduction from the waist to the knee, and the child is encouraged to walk.

Risks attending Reduction. The risks which attend reduction are: fracture of the upper end of the femur or of the neck, the

function of the limb by retaining it for several months in an abducted and hyper extended position. This is secured by manipulation with the aid of tenotomy if necessary.

When the retention appliance is removed exercises and massage are carried out and walking is encouraged.

In older children the degrees of adduction and flexion may be so great that a sub trochanteric osteotomy is demanded. Excision of the femoral head and neck—a procedure sometimes demanded in the painful and arthritic displacement of the adult—is never required during childhood.

THE RACHITIC DEFORMITIES OF THE LOWER EXTREMITIES

RACHITIC DEFORMITIES INVOLVING THE HEAD AND NECK OF THE FEMUR

In the region of the hip joint, rickets may be responsible for the deformities of coxa vara and forward curvature of the femoral neck.

Coxa Vara

THE PATHOLOGICAL ANATOMY OF RICKETY COXA VARA The angle of the neck of the femur in relation to the shaft is diminished in rickets because of the error in ossification which occurs at the junction of the upper epiphysis with the shaft. Shortly before birth the upper extremity of the femur, composed of head, neck, and great trochanter, is cartilaginous without any sign of ossification, so that there is a single mass of cartilage separated from the shaft by a line of ossification which is at right angles to the long axis of the femur. At birth the line of ossification has become more oblique, while it has extended into the lower part of the neck. During the first and second years of life ossification gradually extends so that by the end of the second year the lower half of the neck is ossified, leaving above a



FIG. 28.—The Ossification of the upper End of the Femur (After Pierson)
A At birth B At the end of first year C At eight years D At fifteen years

cartilaginous bridge connecting the head and upper part of the neck to the great trochanter. By the fourth year the line of ossification has reached the upper surface of the neck and this structure is now differentiated, separate metaphyses being formed for the head and for the great trochanter. These facts are made clear on reference to the accompanying diagram.

anterior border of the gluteus medius is exposed. The anterior fibres of the gluteus medius and the underlying minimus are cut across transversely. In the lower part of the wound the anterior border of the vastus externus is exposed, and on following this upwards it leads the operator to the anterior inter-trochanteric line. Careful dissection inwards from this point will expose the capsule, and, as the neck of the femur is usually shortened, the capsule lies much closer to the trochanter than might be expected. The capsule is now incised about half an inch above and parallel to the already exposed inter-trochanteric line, and this wound is enlarged downwards and inwards and upwards and backwards until the misshapen femoral head appears. Outward rotation of the limb brings the head into greater prominence, and the ligamentum teres is divided if it interferes with a proper view of the interior of the capsule.

With the head well rotated it is now possible to obtain a view of the interior of the capsule, and of the hour-glass contraction, if such exists. The anterior margin of the contraction is most marked, and this is divided from within outwards with a probe-pointed knife. The division should include the ilio-psoas, the division being carried carefully downwards towards the lesser trochanter. This exposure enables the operator to view, or at least to pass his fingers inwards and downwards into the true acetabulum. He may decide at this stage to attempt to deepen the acetabulum by a rongeur, as advised in the Hoffa-Lorenz operation or by a Fairbank's bit.

After free division of the capsule, manipulation of the limb generally results in the femoral head passing into the acetabulum with a characteristic click. The opening in the capsule is closed with interrupted catgut sutures. The divided gluteal muscles are sutured, and the skin wound is closed with catgut. Our practice is at once to apply a plaster case in the right-angled position.

From this point the case is treated on the lines already described.

The Smith-Peterson Operation. The Smith-Peterson incision affords excellent access to a hip which is the subject of a congenital dislocation. The incision is made from the anterior spine along the anterior border of the tensor fasciæ femoris to below the level of the great trochanter. The incision is deepened along the plane which lies between the sartorius anteriorly and the tensor fasciæ femoris posteriorly, the fibres of the latter muscle being split.

The original skin incision is now prolonged upwards from the anterior superior spine along the crest of the ilium through the origin of the gluteus medius about half an inch from the superior border of its periosteal attachment. The angled flap so outlined is separated downwards from the ilium by sub-periosteal dissection until the capsule of the hip joint is apparent.

The Treatment of neglected Cases. In cases which have come under observation at an age too old to permit of manipulation or operative reduction, an attempt should be made to improve the

(c) The appearance of the deformity in a child two to three years of age

THE TREATMENT OF RACHITIC COXA VARA Whatever form the local treatment may take, the general condition must not be lost sight of. Anti rachitic treatment will therefore form a part of the therapeutic arrangements, and if there are evidences that the general disease is still active the importance of these general measures can scarcely be over estimated.

Local Treatment The local treatment is conducted on the lines described in the section dealing with coxa vara (p. 1013).

In rachitic coxa vara rest is particularly important, and, if the condition is recognized in its early stages, three or four months' fixation in a double Hamilton splint may be sufficient to arrest or even to correct the deformity. In older children fixation of both



FIG. 529.—Hamilton Splint altered to permit of abduction of right Leg at Hip Joint

limbs in a fully abducted position is indicated, and a double plaster spica or a double Jones's abduction frame are the means by which the position is secured. In fully acquired deformities affecting children above eight years of age operative interference in the shape of cuneiform osteotomy is necessary.

THE AFTER TREATMENT OF RACHITIC COXA VARA Whatever line of treatment may have been adopted and however successful the immediate results, children who have been the subject of rickets coxa vara require careful and prolonged after treatment. There is always the possibility of a relapse and, moreover, the changes which rickets induces in the architectural character of the femoral neck render it liable to injury and to the development of adolescent coxa vara.

The following details should be advised. While exercise is encouraged fatigue is avoided. The more strenuous forms of sport, such as football are not to be recommended in view of the possibilities of injury. The exercises particularly advised are bicycling, horse riding, and swimming. Careful attention is paid to the orthopaedics

The acute stage of rickets is most active at a period which corresponds to the interval between the first and second years of life, a period which anatomically is distinguished by a wide metaphysis extending across the upper end of the femur and a commencing ossification in the centre of the femoral head. When rachitic changes attack this area the process at the inner half of the metaphysis is exaggerated for two reasons—because of the increased vascularity which is associated with the ossification centre in the femoral head and because the support in this area is less perfect than where the metaphysis is superimposed on the upper end of the shaft. The result is that the area of the bone in which healthy ossification is so essential—the under portion of the neck—becomes the site of an exaggerated rachitic change; unhealthy osteoid tissue replaces the healthy developing bone, and the actual keystone in the transmission of weight from the head to the shaft is borne by a bar of cartilage above and an imperfectly ossified tissue below. At this weak area yielding gradually occurs, that portion of the epiphysis which carries the head appears as though it were slipping towards the under surface of the neck, and the process is continued until the deformity is definitely established; as the later stages of ossification proceed the head and neck are modelled upon this imperfect plan. Though walking accelerates and exaggerates the error, the deformity may appear though the child has never walked.

THE CLINICAL FEATURES. If a child who has been the subject of rickets is noticed to walk badly with a swaying gait and everted limbs, a coxa vara should be suspected.

The symptoms are pain and impairment of function of the limb. The pain has certain characteristics—it may be complained of around the hip joint, but it is often referred to the knee and foot. It disappears on rest, to reappear when the patient walks, and it is the result of abnormal tension upon muscles and ligaments. The impairment of function is a disturbance of gait. The patient limps, and in double coxa vara he waddles in a manner closely simulating congenital dislocation of the hip. The affected leg tires easily.

On physical examination other evidences of rickets are noted. The affected limb is found to be shortened, adducted, and rotated outwards. The great trochanter lies above the level of Nelaton's line, while the head of the femur is in its normal position. On testing the passive movements of the hip-joint, extension, abduction and internal rotation are limited.

THE DIAGNOSIS. We are not concerned here with the differential or actual diagnosis of coxa vara, but rather with the characteristics of the rachitic variety. If the clinical features are such as to justify the diagnosis of coxa vara the condition is most likely rickets in its origin if the following conditions are present:

- (a) Other evidences of rickets.
- (b) The bilateral occurrence of the deformity.

is introduced on the internal surface of the bone, which is divided from within outwards. Efficient splintage with slight over correction is then secured.

Knock-knee

(Synonyms *In knee, genu valgum*)

When a normal subject assumes the erect position the line of the

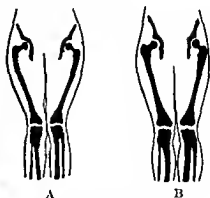


FIG 530—The normal inclination of the Femora (Pfeiffer)

A Female. B Male

femur is directed downwards and inwards, so that it forms an open angle of about 172 degrees with the bones of the leg below the knee. The angle varies with the breadth of the pelvis, it is thus greater in males than in females. The line of the bones of the leg below the knee is practically perpendicular to the plane of the ground, and it therefore follows that as the obliquely directed femur rests upon the vertical tibia, to secure equal apposition of the surface, the internal condyle must be slightly longer than the external. When the downward projection of the internal condyle is increased to an abnormal degree, the tibiae are no longer vertical, the upper extremities incline inwards so that in the erect position the feet are separated when the knees are in contact. This is the deformity of *knock knee*.

VARIETIES OF THE DEFORMITY While rickets is responsible for the majority of cases, it is well to bear in mind that the disease may have other origins, and though these are



FIG 531—Double Rachitic Knock knee (Boy 7 years)

of the lower limbs; a look-out is kept for such defects as flatfoot, and should such arise, steps are taken for their correction.

Anterior Curvature of the Femoral Neck

Anterior curvature or bowing forwards of the neck may occur in association with rickets. Uncomplicated examples of the error are uncommon; in most cases it is an accompaniment of coxa vara or of a rotation deformity of the femoral shaft. Marked eversion of the limbs suggests the deformity. The error *per se* calls for no active treatment, it will improve under the measures which are adopted to correct any related deformities of coxa vara or femur rotation. If active measures are indicated, and the child is resting, the limbs are maintained in a position of full internal rotation; if the child is going about, heightening of the boot sole on the outer side and educating the child to walk slightly intoed will maintain a corrective influence.

RACHITIC DEFORMITIES OF SHAFT OF FEMUR

Two varieties of rachitic deformity affecting the shaft of the femur are recognized—anterior bowing and outward rotation of the shaft. The second is a frequent accompaniment of coxa vara.

THE SITUATION OF THE DEFORMITIES. The anterior bowing occurs in the middle portion of the shaft; the rotation error begins in the upper third, and is continued throughout the length of the femur. Coxa vara, knock-knee, and tibial deformities are usually coincident.

CLINICAL FEATURES. These are sufficiently obvious. If the rotation error is well marked there is eversion of the whole limb (sabre limbs).

TREATMENT. Constitutional treatment and rest produce a striking improvement. It is exceptional to find such extreme deviation of the femur that osteotomy is demanded. While rest is the essential feature of the treatment, if splints are used to secure rest, advantage may be taken of simple mechanical means to aid the correction of the deformity. Inward rotation of the limb will tend to overcome the eversion.

In a case of anterior bowing good results have followed the use of a Thomas's knee splint applied with extension. A master band of strong elastic webbing is applied anteriorly so as to exert pressure over the summit of the deformity, while counter-pressure is applied by posterior bands of domette applied for some distance above and below.

If operation is indicated, the procedure followed is a linear osteotomy. A small incision is made over the centre of the thigh on its antero-internal aspect two fingers' breadth outside the femoral vessels. The incision is deepened to the inner side of the sartorius between the fasciculi of the vastus internus muscle. The limb is placed in an everted position resting on a sandbag. The osteotome

It is difficult to explain why this special portion of the bone should suffer, it would appear to be the result of a stimulation of the inner aspect of the epiphyseal cartilage and, in view of the fact that rickets has been an antecedent factor, it is natural to infer that a rickety change plays some part in the production of the error. Why should the change affect the inner portion of the bone? The hypothesis that the bones in this situation grow more rapidly because they bear less strain and weight cannot be entertained in the light of Wolff's work. A more likely explanation is that the selection of the inner portion of the metaphysis depends on questions of blood supply. Injected specimens show that the vascularity of the inner portion of the metaphysis is considerably greater than that of the outer portion.

While an error in bone growth is the main factor, there are various secondary but very important features. Comparatively early, the internal lateral ligament becomes lengthened and the external ligament shortened, and it is possible that the pull of the former causes a further downward lengthening of the internal condyle, and an exaggeration of the already existing deformity. The picture is that of an error which is partly structural and partly postural.

It is to some extent characteristic of the rachitic type of knock knee that the deformity is not limited to the femur—it is shared by the tibia. Here one may find irregularity of the upper epiphyseal line, and a bending of the shaft so that the internal condylar surface is higher than the external. The upper portion of the tibia may be curved inwards, and the complete diaphysis may be deformed so that, instead of being triangular in section, it is flattened laterally. Spine like projections of bone (McEwan's spines) may arise on the inner border of the tibia below the tuberosity.

Changes in the relations of Femur and Tibia. In well marked knock knee the femur is rotated inwards and the tibia outwards. There is a limitation of the movement of full extension, and this observation is worthy of special attention because it forms a point of distinction between the early rachitic knock knee with which we are concerned and the adolescent type, in the latter hyper extension is generally present.

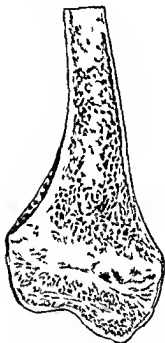


FIG. 133.—Section through the lower end of the Femur in a case of knock knee (Mikulic.)

rare eventualities the possibility of their occurrence is important from the point of view of treatment.

It is possible that a congenital error in the growth of the opposing bones may be the factor at fault; inflammatory bone disease and fracture may have a similar effect. In other cases the primary factor lies in the soft parts, the bone changes being secondary. In this group may be classified the knock-knee which arises from laxity of the knee ligaments and the habitual assumption of the attitude of rest. In this group, too, we find the paralytic knock-knee, which results from paralysis of the muscles on the inner side of the knee with unopposed action of the biceps.



FIG. 532.—Spastic Knock-knee.

An example of spastic diplegia in which a double knock-knee deformity has developed

THE TIME OF ONSET. There are two periods of life at which the deformity may first become apparent — in early childhood, when the erect position is first assumed, and in adolescence, when the factors of growth, body weight, and occupation play their part. The pediatric surgeon is concerned with the first period, when rickets is the responsible factor in some ninety per cent. of the cases.

The deformity is more common in boys than in girls, probably owing to the greater body weight of the former.

THE PATHOLOGY OF RACHITIC KNOCK-KNEE

Changes in the Bones. Under normal conditions the inward inclination of the femur is compensated by the greater length of the

internal condyle. In the deformity of knock-knee the plane of the knee joint is still preserved by an apparent elongation of the internal condyle. It has been stated that an overgrowth of the lower portion of the epiphysis produces the deformity, but, if we examine the lower end of the femur in section we find that the epiphysis, though set at an abnormal obliquity to the shaft, is yet uniform in size, and that the error lies to the inner side of the lower portion of the shaft (metaphysis), where the diaphysis comes into contact with the epiphyseal cartilage. In this situation there is an overgrowth of tissue at the lower extremity of the diaphysis, which is so distorted that the epiphyseal line and the epiphysis are set at an increased obliquity to the shaft.

advantage of by the patient, and it explains the typical bent knee attitude of the disease

The gait in a well marked case is characteristic—it is awkward and shambling. To avoid the 'striking' of the prominent knees at each step the thigh is abducted and rotated outwards at the point of passing its fellow, while the movement is reversed when the limb supports the weight. In severe cases the whole body shares in the movement, swaying from side to side, while the legs are alternately swung outwards and around each other. To compensate for the separation of the feet the gait may be pigeon toed.

Various deformities appear which are secondary to the knee condition. As a result of the outward inclination of the leg, additional weight is thrown on the inner border of the foot, and flat foot develops. This may become so marked as to constitute a pes valgus. It is of interest to note, however, that in extreme degrees of knock knee the efforts of the patient to compensate for the abnormal separation of the legs may result in an habitual inversion of the feet.



FIG 536—Double Rachitic knock knee

The photograph illustrates the method of progression in these cases



FIG 537—Knock knee

A mild degree of rachitic knock knee affecting the right leg



SYMPTOMS Symptoms may be absent but if the deformity is progressive, there is early fatigue and pain at the inner side of the knee



FIG. 534.—Rachitic Knock-knee.

A radiogram of the knee showing the characteristic change in the outline of the median condyle and in the ossification of the inner portion of the epiphysis and metaphysis.

The deformity is most pronounced when the limb is fully extended because the shortened tissue on the outer aspect of the joint becomes tense, and in this position the rotation of the tibia is increased. As the knee is flexed the deformity lessens, until in full flexion it disappears entirely. Flexion disguises the deformity because the posterior surface of the condyle is unaffected, while the relaxation of the peri-articular structures and the outer rotation of the femora permit the tibiae to become parallel. This mechanical disguise is often unconsciously taken

Changes in the Knee Joint. Fibrotic changes have been described in the articular cartilage, especially on the inner portion of the articulation. A chronic synovitis may also be present. Of the peri-articular structures, the tissues on the inner aspect of the joint are relaxed, those on the outer side, the lateral ligaments, the capsule, and the biceps muscle are contracted, and so may resist the reduction of the deformity.

THE CLINICAL FEATURES

Rachitic knock-knee is frequently bilateral, a point of distinction from the adolescent variety, which is generally unilateral. When the child stands, the deformity is characteristic—the lower limbs sag inwards at the knees, while the feet are widely separated.



FIG. 535.—Severe double Rachitic Knock-knee (Boy 7½ years).

below Changes in the contour of the fibula accompany and correspond to the changes in the tibia, the fibular changes being usually less marked in degree

THE DIAGNOSIS OF KNOCK-KNEE

The rachitic knock knee must be distinguished from similar deformities with different origins It is most important, for example, to recognize the paralytic and the traumatic varieties Such distinctions are essential if treatment is to be successful

PROGNOSIS

Parents frequently raise such questions as—What are the prospects of a complete recovery, and is the deformity, even though corrected, likely to be followed by an awkward and erroneous type of gait?

In general it may be said that the prognosis in rachitic knock knee is more favourable than in any other variety of the deformity The answer to the first question depends on the stage at which the deformity comes under treatment If the condition is such that it responds to non operative measures, one is justified in giving an excellent prognosis If, on the other hand, osteotomy or osteoclasis is necessary, the prognosis must be more guarded The answer to the second question will be modified according to whether the deformity is uncomplicated or whether it is accompanied by other deformities, it is also affected by the condition of the ligamentous structures around the knee If the knock knee is uncomplicated and efficiently corrected there should be no subsequent interference with gait, but, if there are complicating errors present, or if the knee ligaments are stretched and loose, an awkward gait may result

TREATMENT

The treatment of rachitic knock knee may be considered under three headings —

- I Expectant treatment
- II Mechanical treatment
- III Operative treatment

I Expectant Treatment This should be the method of choice in small children in the less severe types of the deformity, and when a slight knock knee is associated with some other type of postural deformity such as flatfoot

Expectant treatment includes a wide range of factors The constitutional aspect of the disease is considered and treated A sharp look out is kept for any postural error which may have an exciting effect on the deformity, and in this connection it is a wise precaution to rest the child completely for two or three months General massage of the limbs should be arranged for, in older children simple limb exercises are beneficial, and bathing should also be encouraged

Expectant treatment, however, includes what is really a type

METHODS OF MEASURING THE DEGREE OF KNOCK-KNEE. A simple yet efficient method is to trace the outline of the limbs on paper while the child sits with the legs fully extended; the knees are sufficiently separated to allow the pencil to pass between them. When the child stands erect there will be an increase of the deformity, the increase depending on the laxity of the ligaments and the outward rotation of the tibiae. This increase is estimated by measuring the distance between the two malleoli, the child standing with the knees just separated. A comparison of the standing and sitting inter-malleolar measurements gives an idea of the degree of increase



FIG. 538.—Double Rachitic Knock-knee in child $4\frac{1}{2}$ years old.

Note that the deformity in this instance has occurred in the upper ends of the tibiae and not in the lower ends of the femora.

THE COMBINATION OF KNOCK-KNEE WITH OTHER DEFORMITIES. Flat-foot and coxa vara are often associated with the deformity of knock-knee. The knock-knee may be unilateral or bilateral, and a unilateral type may be accompanied by an outward bowing of its fellow. If there has been a severe precedent rickets, the bones may be twisted and bent in various directions—for example, the femora may be bent forwards and outwards above, and inwards and backwards below, while the tibiae may be bent inwards above and outwards and forwards

different sizes. It is made of ash wood, 2 inches wide, padded through its length on the inner side. It extends from the crest of the ilium to 3 inches beyond the foot sole. It is applied with the limb fully extended, and its application is begun by fastening it securely to the pelvis and the ankle. This may be done by bandages, though at the hip it is an advantage to have the upper end of the splint fitted with a broad pelvic band which buckles round the waist. When the splint is in position the knee is firmly bandaged to it by several turns of a broad elastic webbing. At first there will be a considerable gap between the outer surface of the knee and the splint, but, as the deformity is overcome, this space diminishes. From day to day the elastic bandage is carefully adjusted so as to maintain a constant corrective pull. To begin with, the bandage should be worn continuously except when it is removed for massage or hygienic reasons, in the later stages of the treatment the splints may be removed during the night.

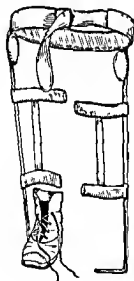


FIG 540 — Thomas's Knock knee Brace with pelvic band as used in bilateral knock knee



FIG 539 — The Thomas's Knock knee Brace of unilateral knock knee

The Thomas's Knock knee Brace. This apparatus consists of a light lateral steel bar provided at its upper end with a pad which rests against the trochanter, while the lower rounded end is turned inwards at a right angle to pass through a 'box' in the heel of the foot. The limb is fastened to the brace in full extension by turns of a roller bandage.

If a single brace is in use the sole of the opposite shoe should be raised by about $\frac{3}{4}$ of an inch—this is essential for comfort in walking.

In bilateral deformities the brace should be modified so that the two splints are united by a pelvic band, this adds to the patient's comfort and permits flexion at the hip joints. An additional advantage of the pelvic band is that by loosening or tightening the posterior strap inversion or eversion of the limb can be induced. In the early stage of the treatment some degree of inversion is required, and, as the knee deformity improves, eversion is gradually induced. Braces which are jointed at the knee should be avoided.

of mechanical treatment, namely, *treatment by manipulation*. This procedure is so important that it is necessary to describe it in detail. It should be carried out morning and evening, for preference after the massage séance. The child is seated, and the deformity is made as obvious as possible by fully extending the limbs. One hand now grasps the knee, the palm being on the inner aspect, the other takes hold of the calf of the leg and gently straightens the knee over the fulcrum of the palm,—the limb is held in the corrected position for a moment. The manipulation is continued with gradually increasing force for a period of ten minutes. It must never be carried to a degree sufficient to cause pain.

Attention should be paid to the condition of the feet. It has been noted how constantly flatfoot is associated with knock-knee, and in advanced cases a varus deformity may exist. It is essential to correct the foot errors, because their correction may have a beneficial influence on the knee deformity. Knock-knee is but an exaggeration of the position of rest, and the foot errors indicate efforts on the part of Nature to withstand and to compensate the knee deformity. Therefore, if flatfoot occurs, means must be taken to correct it.

As recovery becomes evident, bicycle riding and horseback riding are beneficial.

In connection with the expectant treatment a record of the deformity as shown by paper tracings should be kept. The comparison of these from month to month affords an indication of improvement, and so may justify delay in the adoption of more radical measures.

II. Mechanical Treatment. When we speak of mechanical treatment we mean correction of the knock-knee by means of splints or braces. In general the method is indicated in three types of cases—when expectant treatment has failed, when the error is moderate in degree, and in children below the age of five years.

The principle of *mechanical or brace treatment* is the correction of the deformity by the application of pressure applied over the deformity through the medium of a splint or brace.

VARIETIES OF BRACES. Among the large number of splints which have been used, four are particularly useful—the plaster bandage, the lateral wooden splint, the Thomas's knock-knee brace, and the Thomas's calliper splint.

The Plaster Bandage. In young children, while the bones are soft and yielding, the deformity may be corrected by the repeated application of plaster bandages. Under anæsthesia the deformity is corrected as far as possible and the plaster applied. The pelvis is included in the bandage, and inversion of the limb is prevented by incorporating in the plaster a piece of wood which lies at right angles to the limb, and so prevents rotation. The plaster extends downwards to the ankle.

The lateral Wooden Splint is particularly useful in out-patient work. Its cost is small, and it can be stocked in large numbers of

femur It is not suitable for young children, because of the risk of damaging the epiphyseal cartilage, and because the bone is more liable to bend than to break.

The difficulty in using the osteoclast is to ensure that the bone does not fracture at too high a level, so that what is meant to be a supra condylar fracture becomes a fracture through the lower third of the shaft of the femur. One of the varieties of screw osteoclasts is the best, as by its use the situation of the fracture can be more exactly regulated. The lower bar is applied over the external condyle, the upper 3 or 4 inches higher, the limb is firmly held in position by an assistant, and the breaking bar is screwed rapidly home. After fracture, the limb is put up in plaster in a moderately over corrected position, i.e. in a slight genu varum position.

The plaster should be carried far enough to include the pelvis or a small piece of board is incorporated posteriorly across the long axis of the plaster, so as to prevent outward rotation of the limb. The plaster is kept in position for a month or six weeks.

(b) Osteotomy (linear) If operative interference is indicated, linear osteotomy is the method of choice in the majority of cases. It may be carried out by a subcutaneous or by an open method.

The (Lateral) Subcutaneous Operation This operation is performed on the lateral aspect of the limb. A small Vance's osteotome is the only special instrument required. The prepared limb is semiflexed at the knee, and laid with the inner surface resting on a sandbag. The femur is firmly grasped immediately above the condyles, the osteotome is forced through the skin with its cutting edge in the long axis of the femur, or a small preliminary incision is made through the skin and the osteotome is inserted until it comes in contact with the shaft of the bone about 1 inch above the external condyle. While the instrument is held firmly in position against the bone with the left hand, it is turned through a right angle to be transversely and then driven with a mallet through the cortex. A lessened sense of resistance indicates when the medullary cavity is reached, the osteotome is now loosened, withdrawn slightly, and then driven further into the deeper cortex—it must not be completely withdrawn, or its re entrance may be difficult. When the osteolysis is sufficient slight pressure completes the fracture. The osteotome is now with-

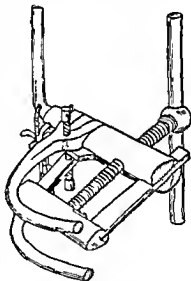


FIG 542—The Grattan Osteoclast

The Calliper Knock-knee Splint. In the treatment of a unilateral knock-knee this is a most excellent apparatus. A Thomas's knee splint of the calliper pattern is fitted with a lateral knee cap attached by adjustable straps to the outer bar of the splint, so that the knee is drawn towards the outer iron. The splint is worn continuously for two or three months, and, as the correction proceeds, the outer iron may be bent slightly outwards so as to induce over-correction of the deformity.

THE DURATION OF TREATMENT BY BRACES AND SPLINTS. The length of time which the treatment entails depends upon a variety of factors—the age of the child, the degree of deformity, and the efficiency of the apparatus employed. On an average six months to one year is necessary. The cure is assured by the gradual adaptation of the parts to the new static conditions.

After the braces or splints have been discarded, the patient must pay attention to the adoption of correct attitudes, and exercise should be encouraged in order to prevent relapse.

III. The operative Treatment of Knock-knee. Any discussion of the operative treatment of knock-knee embraces two questions—What are the indications for operative treatment? and What form is the operative treatment to take?

The Indications and Contra-indications for Operation. The necessity for operation implies the neglect or failure of the preventive or mechanical methods of treatment. It is indicated under the following conditions :

- (1) In children over the age of five years.
- (2) In the more marked types of the deformity.
- (3) If rapid correction is indicated.

Operation is contra-indicated in the early and in the acute stages of the deformity.

THE METHODS OF OPERATION.

Osteoclasis, linear osteotomy, and cuneiform osteotomy are the types of operation practised.

(a) **Osteoclasis.** Osteoclasis is to be preferred if a cutting operation is inadvisable, and if the deformity affects both tibia and

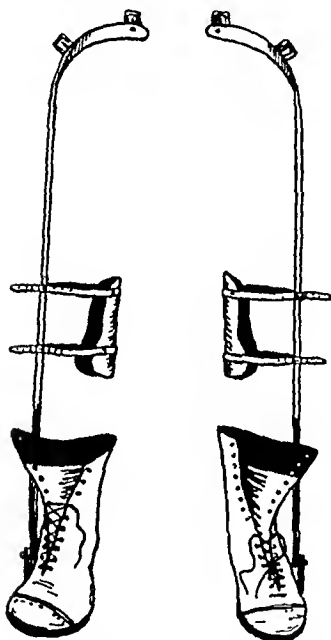


FIG. 541.—Long Braces for Genu valgum. (Bradford and Lovett)

deformity, and in cases in which a tibial deformity complicates the femoral error. In correcting the tibial error a linear division is often insufficient, and a cuneiform operation is therefore necessary.

THE POST-OPERATION TREATMENT After removal of the plaster, massage is begun, the patient meantime remaining in bed. He is allowed to exercise his limbs in any way except in weight bearing. At the end of a week weight bearing is permitted, and walking is gradually resumed. It is advised that the boot soles be raised on the inner side by about $\frac{1}{4}$ inch, and this heightening of the sole should be continued for at least one year after the correction of the error.

Genu Varum (Bowleg)

In a popular sense a deformity which results in a separation of the knees while the ankles are in contact is classified as a bowleg. In more exact terminology *genu varum* is the reverse of *genu valgum*, that is to say, the deformity which has resulted in separation of the knees has occurred in the bone at or near the knee joint, while a *bouleg* is a bending (convex outwards) of the tibia and fibula somewhere between knee and ankle. At first sight it may be difficult to distinguish between *genu varum* and bowleg, but the application of a simple test makes the distinction clear. With the patient erect a vertical line is dropped from the head of the femur (immediately on the medial side of the femoral artery) to the ground. In *genu varum* the line falls inside the knee, while in bowleg the line strikes the knee in the normal position, i.e. through the middle of the patella.

There is a tendency, however, to use the terms *genu varum* and *bouleg* synonymously, because *genu varum* is sometimes a diffuse deformity in which a degree of bowleg co-exists with the deformity at the knee, while in bowleg there is often a complicating *genu varum* owing to strain upon the ligaments of the knee.

ETIOLOGY The majority of the cases are due to rickets. Rare causes are fracture, osteomyelitis, and infantile paralysis.



FIG 545—Rachitic Bowlegs (Girl 6 years old)

Marked lateral curvature together with slight antero-posterior curvature of tibia and fibula. The stunted appearance of the lower limbs is well shown.

drawn, but not before, in case further division is required. The minute wound is closed with a single catgut suture.

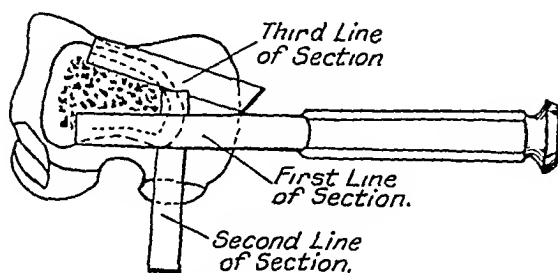


FIG. 543.—Knock-knee. (McEwan.)

The lines of section of the bone in the operation of osteotomy.

about $1\frac{1}{2}$ inches long is made above the internal condyle in the line of the fibres of the vastus internus muscle, the centre of the incision being on a level with the adductor tubercle. The muscle is split until the sub-muscular cellular space is exposed. The adductor tubercle is now recognized, or, if the landmark is not sufficiently clear, its situation is indicated by a branch of the anastomatic artery, which runs across the bone at this level to join the lateral vessels. The periosteum is incised above the level of the tubercle, and the bone is divided with an osteotome; the same precautions are taken as in the operation of linear osteotomy. When the division of the bone is complete the split muscle is approximated with catgut and the skin is closed. A plaster case, extending from the waist to the ankle, is applied and retained in position for four weeks.

(c) **Cuneiform Osteotomy.** The removal of a wedge in association with the division of the bones is rarely practised. The operation is sometimes recommended in extreme degrees of the

The Open Operation (Mesial). This operation is widely practised, and it is the method of choice in the Edinburgh School. The operation is performed on the mesial aspect of the limb. The semi-flexed knee is placed with its lateral surface resting on a small sand-bag, an oblique incision



FIG. 544.—Rachitic Bowlegs (Girl aged 5 years).

Expectant Treatment In the slighter examples of the disease gradual manual correction gives good results. The leg, grasped firmly at ankle and knee, is at intervals submitted to a steady corrective force which eventually overcomes the error. The method can be carried out by an intelligent parent, though they rarely have the courage to use sufficient force to make the method efficient.

Expectant treatment is with advantage combined with *splint and brace* methods. It is sometimes recommended that the boot soles be heightened on the outer side by a thickness of about $\frac{1}{4}$ inch. This tends to correct the deformity, and at the same time to overcome the accompanying pigeon toe gait. In using the measure care must be taken to avoid the development of flatfoot.

Treatment by Splints and Braces If expectant treatment has failed, or if the deformity is fully established when it comes under observation, some type of corrective apparatus should be employed.

Lateral wooden Splints
In hospital practice, where expense is an important consideration, lateral wooden splints, somewhat similar to those recommended for knock knee, may be used. The splints are applied to the outer surface of the limb. They extend from the iliac crest to beyond the foot, they are secured round the waist, a large pad is placed opposite the knee, and the foot is fastened to the splint with turns of an elastic bandage. At first the splint is worn constantly except when removed for bathing or massage, later, as improvement is established, it is worn only at night.



FIG 547—Genu varum Deformity with associated slight bowing of both legs

The Napier Brace This is the appliance which we particularly favour. A light metal bar, jointed opposite the hip joint, extends from immediately below the iliac crest to the upper third of the thigh. An inner straight bar extends from the foot to the upper third of the thigh, where it is joined to the outer bar by a thigh band. The inner upright is provided with a canvas lacing, which surrounds the knee and the upper part of the leg and draws the limb into the correct

PATHOLOGY. The deformity in genu varum is the reverse of that in genu valgum. The femur is abducted and rotated outwards, while the tibia is rotated inwards. The internal condyle of the femur and the internal tuberosity of the tibia bear the greater portion of the weight at the knee. The relationship of the condyles of the femur is altered so that the outer condyle is either on the same level or is lower than the internal, while the external tuberosity of the tibia may be somewhat higher than the internal. A spiral twist may be present in the femur.



FIG. 546.—Double Rachitic Bowlegs (Child 4 years old).

pigeon-toe gait tends to occur.

Genu varum may be unilateral or bilateral, and a unilateral deformity may be associated with a genu valgum of the opposite limb.

TREATMENT

The general outlines of treatment are similar to those indicated in genu valgum, but there are two distinctions—braces have a wider sphere of usefulness, and the eventual prognosis from their use is promising. The lines of treatment may be summarized as expectant, splint and brace treatment, and operation.

CLINICAL FEATURES.

The deformity is evident, and the test already mentioned demonstrates the exact locality. It has been mentioned how in genu valgum the deformity disappears on flexion of the knee; in genu varum there is an interesting change, for, if the limbs are flexed and the mesial aspects of the knees are placed in contact, the malleoli are separated and a knock-knee simulated. The deformity is explained by the internal rotation of the femora, the result of bringing the inner surface of the knees in contact. The gait is strong and active; in distinction to the gait of knock-knee, it may be described as 'rolling,' because each foot describes part of the arc of a circle before reaching the ground; a

Anterior Bowleg

Anterior bowleg or anterior curvature of the tibia is only met with in association with rickets, and as a rule the deformity is accompanied by other errors of the lower limbs, such as knock knee and torsion deformity of the femora

PATHOLOGY The tibiae are bent forwards and flattened laterally, alateral or median convexity may also be present

SYMPTOMS Owing to the forward displacement of the leg bones the gait has an appearance as though the patient were sinking forward at each step. The feet are flat, and the heels appear to be unusually long. The child tires easily.

TREATMENT This deformity generally requires to be treated by operation, as conservative and expectant methods are rarely successful.

Cuneiform osteotomy of the tibia, accompanied by tenotomy of the tendo Achilles, permits the most perfect correction. If an osteoclasia is done there may be difficulty in retaining the fragments in position. The after treatment is similar to that followed in connection with the operation for bowlegs.



FIG 550 —Rachitic Deformities of the lower Limbs (Boy 5½ years)

The right leg shows a marked degree of lateral curvature while the left leg is the site of an antero-posterior curve

OSCOOD-SCHLATTER'S DISEASE

(Injury to the tibial tubercle)

In childhood and adolescence the tongue like prolongation of the upper tibial epiphysis is liable to be separated from its attachment

position. A special point in favour of this splint is the fact that it is ambulatory (Fig. 548).

The Boston long Brace. Bradford and Lovett recommend the Boston long brace. An inner iron, jointed opposite the ankle joint, is secured to the boot sole, while above it curves upwards and outwards below the groin to a point on a level with and behind the trochanter. If a double splint is applied, the posterior extremities are united by a strap passing across the buttocks, adjustment of which permits eversion of the limb if desired.

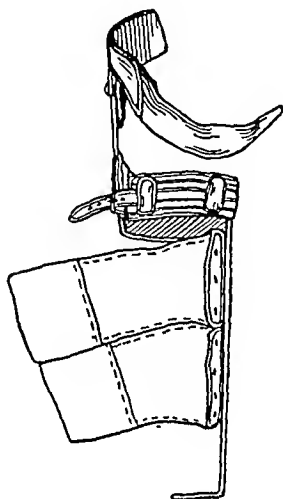


FIG. 548.—The Napier Brace, used in the correction of genu varum and bow leg.



FIG. 549.—The Knight Brace, used in the correction of bow leg.

The Knight Brace. This splint is of use when the distortion occurs in the lower third of the tibia. Two uprights are attached to a foot-piece, the inner upright being provided with a pad at its upper end, which exerts pressure on the inner condyle of the femur, the outer bar reaching to the head of the fibula. At a level immediately below the knee joint the vertical bars are joined by a leather band and buckle. When the splint is in position the leg is drawn towards the inner upright by means of a canvas lacing.

Operative Treatment.

Operation should not be attempted until the child is over five years of age. The deformity is corrected by osteoclasis or osteotomy. Osteoclasis is preferable in young children, and the fracture is induced at the point of maximum deformity.

Osteotomy is easy and satisfactory. The osteotome is inserted on the inner aspect of the tibia at the point of maximum deformity, and the division is

completed by manual force.

In three or four days, when swelling has subsided, the limb is encased in plaster and the child is permitted to walk. The plaster is removed at the end of six weeks, and as a rule no apparatus is required in the after-treatment unless laxity of the knee has accompanied the bony error, in which case a lateral iron may be worn for six months.

DISABILITIES AND DEFORMITIES OF THE FEET

Disabilities of the feet play a large and important part in the group of cases which may be termed 'the orthopædics of infancy'. Before discussing the individual errors and deformities it is necessary to consider the general principles, mechanical, physiological, and pathological, which control the various functions of the human foot.

The Foot and its Functions The foot fulfils two functions—one is passive and weight bearing, the other is active and concerned with the forward propulsion of the body in walking, and to these functions the foot responds in different and distinctive ways. The methods of response mainly depend upon the arches of the foot, and it is therefore appropriate that a short description of these anatomical arrangements should be given.

The orthopædist recognizes the existence of four arches—the longitudinal, the transverse, the anterior metatarsal, and the internal.

The *longitudinal arch* is in the long axis of the foot. It extends from the internal tuberosity of the os calcis to the head of the first metatarsal bone, and it is most manifest at the mediolateral edge of the sole, though it extends laterally for some distance. Its highest point is opposite the talo navicular joint. The arch consists of two limbs—a short posterior limb extending from the internal tuberosity of the os calcis to the talo navicular joint, and a long anterior limb which extends from the talo navicular joint to the head of the first metatarsal bone. This arch is a permanent one, its length and depth vary under different conditions and in different individuals, but any very evident interference with it should be accepted as pathological.

The *transverse arch* is also a permanent one. As Ellis has pointed out, it can be best appreciated when considered in relation to both feet. If a plaster imprint is taken while the medial edges of the feet are in apposition, and if the cast is sawn through transversely opposite the talo-navicular joint, a flattened arch becomes apparent. From the lateral edge of the sole it rises gradually towards the medial edge of the foot when it begins to ascend more acutely until it reaches its maximum at the level of the talo navicular joint. Each foot, therefore, forms one half of the arch, and it has no true summit, as the internal malleoli normally prevent the edges of the foot from coming into contact at the level of the talo navicular joint.

The *anterior or metatarsal arch* is a temporary one—that is to say, it disappears under the function of weight bearing. It extends transversely across the foot at the level of the heads of the metatarsal bones. The summit of the arch is formed by the second and third metatarsals while the respective pillars are the heads of the first and fifth metatarsals.

by the pull of the quadriceps extensor muscle. The symptoms and signs of such a condition are local pain and tenderness, apparent enlargement of the tubercle, and hypertrophy of the sub-ligamentous pad of fat. X-ray examination shows a degree of separation of the tibial epiphysis, while the ossification of the process is often interfered with.

DIAGNOSIS. It is a wise precaution to X-ray both knees, as the



FIG. 551.—Osgood-Schlatter's Disease of upper Epiphysis of Tibia (Boy 10 years old).

condition is often bilateral, though only one limb may show the effects of the lesion.

TREATMENT. If there is much pain the limb should be fixed in plaster for three months, the knee being extended. Chronic cases improve if flexion is prevented by the wearing of a knee cage. If actual displacement is present open operation for reduction and re-attachment is indicated.

of rest the feet are abducted to a varying degree, the muscles are relaxed, the ligaments taut, while the bones are more closely approximated, so that the longitudinal arches appear to be lessened in depth. The persistence of this attitude constitutes the condition of weak foot or flatfoot.

PATHOLOGY

The changes associated with the deformity are as follows:

The leg is displaced inwards so that the weight falls on the inner side of the foot, while the limb is rotated inwards so that a vertical line drawn through its centre falls to the inner side of the great toe instead of over the second toe.

There is an important change of relationship between the bones: the talus is rotated downwards and inwards upon the calcaneus, the antero-internal border of the former bone is depressed upon the inferior calcaneo-scapoid and deltoid ligaments, and the navicular is depressed with the head of the astragalus. These bony changes are accompanied by alterations in the contour of the foot.

Under weight bearing the longitudinal arch is depressed — indeed, there may be an inward hinging of the inner side of the foot, so that the entire sole rests upon the ground. The waist of the foot is broadened, the heel projects, the prominence of the median malleolus is increased, while the outline of the lateral malleolus is obscured.

Movements are not interfered with unless the condition is an advanced one in which event adduction and plantar flexion are limited.

On testing the passive movements of the foot it is often found that when passive dorsal flexion is carried out, some permanent shortening of the tendo Achilles is demonstrated. This is an important finding, for even a slight degree of permanent shortening of the heel tendon may cause abduction and subsequent breakdown of the foot.

In long standing cases various adaptive changes occur. Ligaments on the inner aspect of the foot and ankle joint are stretched and weakened, the bones may show evidence of periostitis, and the internal structures may be altered, the disused muscles are atrophied.



FIG. 552 — Double Congenital Flatfoot

The *internal arch*, like the anterior metatarsal, is a temporary arrangement, in so far as it disappears under weight-bearing. It is formed by the inner border of the foot, and it is slightly convex outwards. The inner edge of the foot becomes straight when it is bearing weight, but under certain pathological conditions an arch convex inwards may appear.

The Movements of the Foot. The primary movements of the foot are four in number—dorsal flexion, plantar flexion, adduction, and abduction. The movements of abduction and adduction occur at the mid-tarsal and the sub-astragaloid joints, those of plantar and dorsal flexion are concerned with the ankle joint except in so far as extreme plantar flexion is combined with slight adduction and extreme dorsal flexion with abduction, and therefore some degree of mid-tarsal and sub-astragaloid movements occur in association with the ankle-joint movements.

The Foot as a passive Support. We have said that the foot serves two separate purposes, and that its shape and use in these functions vary. When the individual stands erect the function of the foot is that of a pedestal—the affording of passive support to the body weight, a state in which muscular action is limited to the maintenance of balance. In this position the ligaments are stretched and tight, while the various joints of the foot are so strongly apposed that the foot is said to be ‘locked’ into a rigid whole. In this action the various arches of the foot are lessened, and it is important to appreciate that they are lessened, not because the supporting ligaments are stretched, but because the related bones have glided one upon another to a somewhat lower level.

The Foot as an active Support. The second function of the foot is that of assisting the leg in the forward propulsion of the body. Here it is an active mechanism, and, in contrast with passive weight-bearing, ligamentous strain is at a minimum, while the muscles are in full action, the arches are restored, the joints are ‘unlocked’ and in an ‘easy’ or middle attitude—the whole picture is one of alertness and readiness for instant action.

In walking the feet are held parallel to one another, the line of strain falling through the middle of the foot from the centre of the patella through the space between the second and third metatarsal bones. As the foot is advanced the weight is borne upon a succession of structures, beginning with the heel and thence along the outer border of the foot. The heel is then raised, the body is lifted over the toes, the great toe giving the final impulse to the step.

FLATFOOT

It has been well said that the persistence of the passive attitude of abduction is the real error in the condition of flatfoot. In the attitude

of rest the feet are abducted to a varying degree, the muscles are relaxed, the ligaments taut, while the bones are more closely approximated, so that the longitudinal arches appear to be lessened in depth. The persistence of this attitude constitutes the condition of weak foot or flatfoot.

PATHOLOGY

The changes associated with the deformity are as follows:

The leg is displaced inwards so that the weight falls on the inner side of the foot, while the limb is rotated inwards so that a vertical line drawn through its centre falls to the inner side of the great toe instead of over the second toe.

There is an important change of relationship between the bones: the talus is rotated downwards and inwards upon the calcaneus, the antero-internal border of the former bone is depressed upon the inferior calcaneo-scapoid and deltoid ligaments, and the navicular is depressed with the head of the astragalus. These bony changes are accompanied by alterations in the contour of the foot.

Under weight bearing the longitudinal arch is depressed — indeed, there may be an inward bulging of the inner side of the foot, so that the entire sole rests upon the ground. The waist of the foot is broadened, the heel projects, the prominence of the median malleolus is increased, while the outline of the lateral malleolus is obscured.

Movements are not interfered with unless the condition is an advanced one, in which event adduction and plantar flexion are limited.

On testing the passive movements of the foot it is often found that when passive dorsal flexion is carried out, some permanent shortening of the tendo Achillis is demonstrated. This is an important finding, for even a slight degree of permanent shortening of the heel tendon may cause abduction and subsequent breakdown of the foot.

In long standing cases various adaptive changes occur. Ligaments on the inner aspect of the foot and ankle joint are stretched and weakened; the bones may show evidence of periostitis, and the internal structures may be altered, the disused muscles are atrophied.



FIG 5.2 — Double Congenital Flatfoot

ETIOLOGY

Weakening of the muscles, stretching of the ligaments, alteration in the relationship between individual bones is the sequence of events as far as the pathological changes are concerned, and therefore influences which tend to induce the first phase of the sequence would seem to be the most fertile cause of the deformity. Rickets, diseases associated with general debility, confinement to bed over a long period of time, and disproportionate increase in body weight are common causes of the error.

In certain children the joints of the foot, in common with other parts, are abnormally lax in their arrangement, a state of affairs to which the designation of congenital flatfoot is sometimes given.



FIG. 553.—Congenital subluxation of the Astragalus.
There is also an error in the ossification of the epiphysis of the calcaneus.

In certain cases of this class there is a congenital displacement or subluxation of the astragalus.

Injury to the foot through wearing unsuitable shoes, by allowing a child to walk too soon, by permitting it to stand too long, to walk too far, or to assume incorrect attitudes of walking and standing are predisposing causes of great importance. Deformities of the legs (knock-knee or bowlegs) may be accompanied by weakness of the feet.

SYMPTOMS

The error is often a symptomless one as far as subjective features are concerned. In older children, fatigue, weakness, and awkwardness in walking are frequently complained of, but even in these cases pain

is usually absent, in this respect the condition differs from the flatfoot of later life. Awkwardness in walking—an out toed or in toed gait—is often the first feature to be noticed, or the parents' attention may be attracted by the falling of the foot arch or the obvious bulging of the inner edge of the sole.

EXAMINATION AND PHYSICAL SIGNS

The examination is begun by observing the manner of standing and walking. In a characteristic case the feet are everted, the child treads heavily on the heels, while the gait has a distinctive 'stamping' character. When the shoes are investigated the inner side of the sole is found to be worn while the golosh is weakened and bulging.



FIG. 554.—Congenital subluxation of the Astragalus.
An example of a bilateral deformity in boy 2½ years old.

The child now stands barefooted facing the examiner, and a vertical line is drawn from the centre of the patella down the crest of the tibia. Its lower end should pass over the space between the second and third toes, if it should lie to the inner or the outer side of the great toe the foot is displaced in abduction or adduction, and is therefore in a position which exaggerates any existing deformity. The contour of the weight bearing foot is observed, the slight concavity which exists under normal conditions when the feet are placed side by side and with their medial borders in apposition may be replaced by a bulging convexity. The range of movement is tested, and the movements of plantar and dorsal flexion, of adduction and abduction are investigated actively and passively, the limb being held with the knee in full extension. The importance of shortening of the tendo Achilles has been alluded to. For

purposes of record an impress may be taken of the weight-bearing sole, as shown by an imprint upon smoked paper, and this impression is compared with the normal standard.

It is advisable at this stage to classify the degree of deformity which exists, and we use the following grouping :

- (1) *Pes valgus*, or abduction deformity, the error disappearing when the foot is fully plantar-flexed and adducted.
- (2) *Pes planus*, in which the flatness of the foot is the most noticeable error. This type is met with in children who are learning to walk, and it probably depends upon a congenital weakness of the supporting ligaments.
- (3) *Pes valgo-planus*, in which the abduction error overshadows the arch depression.
- (4) *Pes plano-valgus*, where the depression deformity outweighs the abduction error.

The term *voluntary*, *passive*, or *rigid* may be applied to these deformities according to whether the error can be corrected by a voluntary change in position of the foot, by manipulation on the part of the examiner, or yields only to powerful mechanical force.

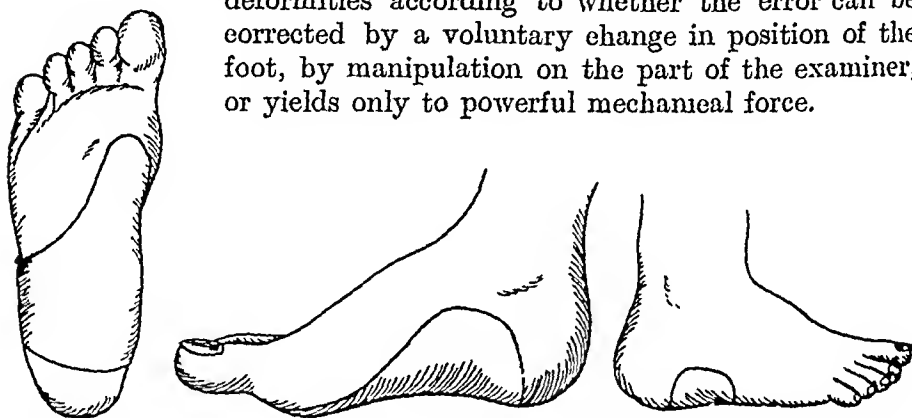


FIG. 555.—The Whitman Support as used in the correction of antero-posterior Flatfoot. (Whitman.)

DIAGNOSIS

In the majority of cases no difficulty will arise in the recognition of the disorder, but the examiner must be alert to the possibility of confusing simple flatfoot with a deformity which, while similar in appearance, is secondary to an independent disease. Infantile paralysis of the calf muscles may be associated with flatfoot. Potts' fracture, fracture of the tarsal bones, and chronic inflammatory disease of the ankle joint or tarsus may be complicated by the appearance of this error, and it is obviously important that orthopaedic errors of this description should not be confused with the simple static disability.

TREATMENT

The object desired is so to improve the musculature of the foot that normal function and attitude is restored, while the contour of

the foot regains its healthy appearance. This is attained by following certain simple principles

- (a) By correcting any obstruction which prevents the foot from performing its full range of passive and active movement
- (b) By so developing the muscles that the future efficient functional use of the foot is assured

(a) **The Correction of restricted Movements** In estimating the efficiency of a foot, regard must be paid to the extent of passive movement in its individual joints, and particularly in the ankle, sub astragaloid, and mid tarsal joints. Any restriction to the normal range of movement should be rectified. This is particularly important where dorsiflexion is concerned. To overlook a shortened tendo Achilles in a case of flatfoot is to render the usual remedies unsuccessful.

In order to demonstrate the existence of short heel tendons the child should be made to stand with the feet parallel and well adducted and the knees fully extended, if there is any shortening the child will then tend to fall backwards.

Slight degrees of the error yield to passive stretching or to the active stretching which results from walking up an incline with the knees straight and the feet intoed. More resistant cases are treated with a light metal night splint, the foot being strongly dorsiflexed and inverted. If simple measures fail a subcutaneous tenotomy of the tendo Achilles may be necessary.

Restrictions situated in the sub astragaloid and mid tarsal joints are infrequent in childhood, but if encountered they are corrected by manipulation.

(b) **The Restoration of normal Function** This implies a variety of considerations

(1) *Improve the general Hygienic Condition*

Poor health, insufficient food, too much standing lessen the efficiency of the foot in relation to the work demanded of it, and efficient treatment must include the correction of errors of this description.

(2) *Institute a Foot Drill which will re educate the Foot*

If the child is old enough this instruction is of great importance. In a correct walk the medial borders of the feet are parallel except at the end of the stride, when the big toe should turn in towards the midline and the impulse to the next step be made by the balls of all five toes and by the toes themselves. As the weight is taken by the advanced foot it passes from the heel to the outer border of the foot and thence to the toes. The stride should be slow and short, and, if properly carried out, walking affords a heel and toe exercise of the best type.

(3) Improve the Nutrition of the Muscles.

Massage, alternate douching in hot and cold water, and exercises are the means by which the muscle tone is improved.

The type of exercise may have to be modified according to the age of the child, but small children can be educated to carry out tip-toe exercises, rising on the outer edge of the foot, grasping a fluff ball with the toes, and rubbing out the periphery of a chalk circle with the great toe of one foot while standing on the other in the centre of the circle: the radius of the circle should be the length of a full stride. Bicycling is the best outdoor exercise.

(4) Improve the Footwear.

The proper shoe should contain sufficient space for the independent movements of the toes. The heel should be moderately high, because the plantar flexion thereby induced produces some degree of adduction, while the curvature of the long arch is increased. The height of the heel must, of course, be kept within reasonable limits; besides being high, it should be broad, and the 'Brogue' pattern is the best. The waist of the shoe should be strong and well-curved, and that part of the upper which lies along the inner border of the foot between the heel and the big toe (the golosh) should be specially strengthened by an extra leather in the sole for the purpose of supporting the inferior calcaneo-scapoid ligament and the related overlying bones.

The shoe may be further improved by the method of 'wedging' the inner border of the sole and heel. An additional piece of leather $\frac{1}{8}$ to $\frac{1}{4}$ inch in depth is fastened along the under-surface of the sole and heel, and the heel may be brought forward on the inner side so as to further support the waist.

(5) The Use of Supports.

There is no doubt that many cases benefit from the use of supports. Whatever form they take—whether the individually fitted Whitman model (Fig. 555), or the ready-made arch support—it is essential that they are comfortable and well-fitting: in small children a rubber support is often helpful.

Operative Treatment. Operative treatment in children is practically confined to the severe pes planus and usually congenital type of deformity. In those cases in which simpler methods have been tried without success, good results have been recorded from an open operation designed to shorten the inner ligaments and the tibial tendons and to lengthen the tendo Achilles. The inferior calcaneo-scapoid and deltoid ligaments are pleated and shortened, the tendon of the tibialis posterior is shortened, the tendon of the tendo Achilles is lengthened, and a slip from it is transplanted into the tibialis posterior.

The foot, fully adducted and at right angles to the leg, is put up in plaster for six weeks, and walking is afterwards permitted in boots which have been specially prepared by the addition of sole wedges, arch supports, outside steels, and T-straps.

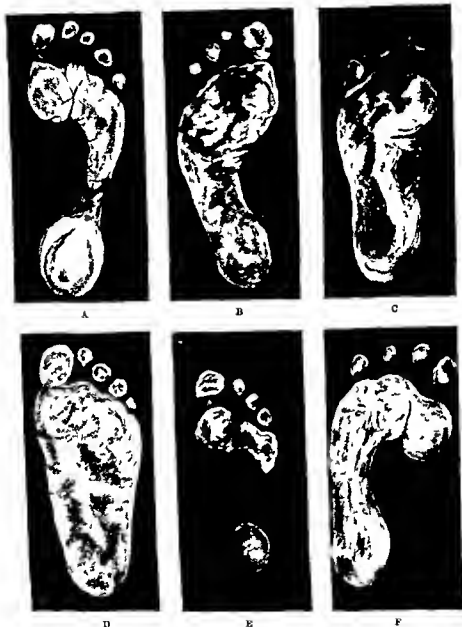


FIG 556—Deformities of the Foot The various appearances of Sole Impressions

A Normal foot B Commencing flatfoot C Moderate flatfoot D Severe flatfoot
 E Pes calcaneus F Pes excavatus (cavus) (After De Quervain)

Rigid Flatfoot

Flatfoot which has reached the rigid stage is uncommon in childhood. The only examples which we have seen have been in association with arachnodactyly.

The condition is treated on the same lines as those employed in adult cases. Restoration of the arch by manipulation or wrenching,



FIG. 557.—Arachnodactyly (Boy 9½ years).

Notice the abnormal length of the feet and particularly of the great toe.

maintenance of the correct position by plaster, and later by supports, while an attempt is made to subsequently keep the foot mobile by massage and graduated exercises.



FIG. 558.—Arachnodactyly.

Note the abnormal length of hands and feet. A congenital dislocation of the lenses in both eyes accompanied the changes in the extremities.

Anterior or Metatarsal Flatfoot

The disability which results from dropping of the anterior metatarsal arch, while met with in children, is not the symptomatic condition which it is in adults. The reason probably is that the falling of the arch, and the great toe deformity which so often accompanies it, is so largely a 'boot' deformity that there is neither opportunity nor time for it to become fully established during the years of youth.

Children who show a tendency to the development of this error should have special attention paid to the condition in case it develops into a rigid flatfoot with an associated metatarsalgia. The important points are

- (1) Avoid the use of too high heels
- (2) Provide moderately thick-soled boots, the soles being flat from side to side, but curved from before backwards (rocker soles)
- (3) A metatarsal bar may be fastened obliquely across the sole immediately behind the position of the metatarsal heads
- (4) Circular adhesive supports may be applied behind the heads of the metatarsal bones (Goldthwait's bands)

Contracted or Hollow Feet

The period of late childhood is the time when the deformity of hollow foot first becomes apparent. The deformity may be defined as an exaggeration in the depth of the longitudinal arch of the foot, combined sometimes with a limitation in the amount of dorsal flexion.

The term '*talipes arcuatus*' or *pes cavus* is applied to the uncomplicated hollow foot, a *talipes plantaris* is that in which a limitation of dorsal flexion accompanies the arch error.



FIG. 559.—Double *pes cavus* (spastic in its origin)

ETIOLOGY Many examples of the condition are inherited, and a disproportion in growth between bones and muscles has been suggested by Griffith as being the mechanical explanation of the deformity. In many cases an attack of poliomyelitis in earlier years has been the responsible factor by weakening the extensors so that slight dropfoot occurs, while secondary contraction of the muscles of the sole and calf produces the deformity.

The use of too high heels and the role of the professional dancer are effects exercised in later life rather than in childhood.

SYMPTOMS There may be no subjective symptoms. A difficulty in fitting comfortable shoes is often the first feature to attract attention. The walking may be awkward, and as the child grows, pain may be complained of, and corns may develop on prominent parts.

EXAMINATION The increased depth of the longitudinal arch is a distinctive feature, the skin over the heel and the heads of the

metatarsal bones is thickened, the toes are dorsiflexed and callosities are often present on their upper surface; the plantar fascia is contracted, and may be tender to touch. Limitation of dorsiflexion is characteristic of the talipes plantaris type of the disease.

TREATMENT. Treatment should begin as soon as the error is recognized. Methodical stretching and massage will often succeed in relieving the contraction, and the wearing of a metatarsal bar may be of benefit. In more resistant cases subcutaneous division of the plantar fascia may be necessary, or the foot may require to be wreathed into a correct position. If the case is bad enough to demand operative interference, the Steindler operation of stripping the os calcis is effective.

Steindler's description of the operation is as follows:

'A horseshoe incision is made around the heel, beginning from the inner tubercle of the os calcis and ending about three-quarters of an inch behind the calcaneo-cuboid joint. The under surface of the os calcis is stripped entirely to its anterior edge where the short flexors of the toes and the abductors of the first and fifth toes are inserted together with plantar fascia. . . . Underneath these structures a grooved director is passed, and they are severed or stripped close to the bone. Thereupon the cavity of the foot at once yields to extension up to the point where the contraction of the accessory flexor and of the long



FIG. 560.—Congenital Contraction of the Toes (Girl 12 years old).

plantar ligament is responsible for the cavus deformity."

Contraction of the tendo Achilles is overcome by stretching or division; the malposition of the toes is corrected by manipulation or by division of the shortened extensor tendons. A plaster bandage applied with a thin sole board holds the foot in position and corrects the contracted toes. The child is encouraged to walk early, and the plaster case is kept in place for six weeks. Afterwards massage is continued, and a long steel footplate with a convexity beneath this metatarso-phalangeal articulation helps to maintain the normal contour.

Hallux Varus

Adduction of the great toe (hallux varus) is an error occasionally met with in babies. It is a rare deformity sometimes associated with

club-foot, knock knee, and congenital absence of the fibula. In certain cases it appears to be associated with hypertrophy of the adductor muscles, in which event the great toe has a certain amount of prehensile power.

TREATMENT The deformity is usually corrected when a shoe is worn. Cases which persist are improved by the fixation of a strip of adhesive plaster applied so as to maintain the toe in the correct position.



FIG. 561.—Congenital double Hallux varus (Baby 9 months)
(Miss Herzfeld's case)

Metatarsus Varus (Froehch)

This is a deformity in which the metatarsus is adducted on the tarsal bones. The error frequently accompanies congenital talipes equino varus, in other instances it may be compensatory to a valgus deformity.

TREATMENT Slight degrees of the deformity yield to manipulation and to raising the inner side of the boot sole, severer cases demand wrenching and corrective appliances.

The condition was originally described by Volkmann as a congenital deformity of the tibio tarsal joint.

Hallux Valgus¹

Hallux valgus is a deformity in which the great toe is turned outward to an exaggerated degree. It is usually an affection of adult

¹ It is interesting to note that 75 per cent of cases of myositis ossificans progressiva show a congenital displacement of the great toe resembling a Hallux valgus.

life, though examples are occasionally met with in children. We have seen several cases in which the deformity was congenital, and virtually amounted to sub-luxation of the metacarpo-phalangeal joints.

TREATMENT. Shoes as wide as the weight-bearing foot in front with a straight inner edge should be worn; separate-toed stockings are useful. A light internal splint may be required to maintain the bones in the correct position. Operative interference is rarely necessary.



FIG. 562 —Double Congenital Hallux valgus (Baby 3 weeks old).

KÖHLER'S DISEASE

In 1908 Kohler¹ described a disease of the tarsal scaphoid which has since been associated with his name. The result demonstrates the folly of associating an individual's name with a disease—Köhler has described, and therefore his name is sometimes applied to a pathological condition of the metatarsal bones, and it is obvious how easily confusion may arise.

Tarsal scaphoiditis or Kohler's disease is a chronic condition of the tarsal scaphoid associated with certain disabling symptoms, and terminating in an increased density and diminished bulk of the bone.

ETIOLOGY. It is curious that the disease should be so sharply limited to the scaphoid, but certain peculiarities of structure and position may explain the incidence. The scaphoid is the last bone in the foot to ossify; it has a bilobed nucleus, and, being the keystone of an arch, it is subjected to an unusual amount of pressure. Yet some selective influence must be at work apart from these considerations, because the disease is usually unilateral.

Froelich² has recounted the frequency with which growth errors

¹ Kohler, A.: *Münch. Med. Woch.* 37, 2923, 1908.

² Froelich: *Des Apophysitis de Croissance*—*Par. Med.* 10, 130, 1920.

of the scaphoid are encountered apart from Kohler's disease, the reason apparently being the bilobed nucleus, and he insists on the importance of always examining both feet before classifying the scaphoid condition as a Kohler's disease

The exact origin of the disease remains doubtful, Schultz¹



FIG 563—Tarsal scaphoiditis (Kohler's disease)

The right foot is the site of a tarsal scaphoiditis which has been in existence for eighteen months. The condensation and fragmentation of the bony nucleus is well shown.

believed that a compression fracture originated every case, but Moffat,² by tracing an individual case showed that there was no fracture apparent

¹ Schultz *Arch für Klin Chir* 100 431

² Moffat *Jour Am Med Assoc* 80, 87 90, 1923

Preiser,¹ judging from the analogy of Kienboch's traumatic softening following fracture of the semilunar bone, believed that the compression of the bone which proceeds from its peculiar position resulted in an interference with the blood-vessels, a resulting nutritional disturbance, and ultimately a distortion of the bone outline. Mouchet



FIG. 564.—Disease of the Epiphysis of the Os calcis (Boy 14 years).

Similar to the process which occurs in Perthes' disease or Legg's disease of the hip joint, the Osgood Schlatter disease of the upper epiphysis of the tibia, and the Kohler's disease of the tarsal scaphoid. The symptoms and signs are pain and swelling of the heel and tenderness on pressure.

and Roederer² explain the disease in a very similar way. They believe in a pre-existing dystrophy of the bone, possibly the result of a vascular disturbance, and a subsequent pathological fracture. Fassett³ claims that the condition is tuberculous, but numerous

¹ Preiser: *Fortschr.-a.-d.-Geb.*, A Röntgenstrahlen 17, 360, 1911.

² Mouchet and Reederer: *Rev. d'Orth.*, 7, 289, 1920.

³ Fassett: *J. Am. Med. Assoc.*, 62, 1155, 1914.

investigations have disproved the claim Pfahler and Hetzel¹ describe the condition is an inflammatory osteitis and osteochondritis. The result of our own experience has led us to regard the condition as an inflammatory one. In one case which we observed over a long period of time an abscess eventually developed, from which a long chained staphylococcus was isolated.

PATHOLOGY The exact nature of the pathology, as far as its

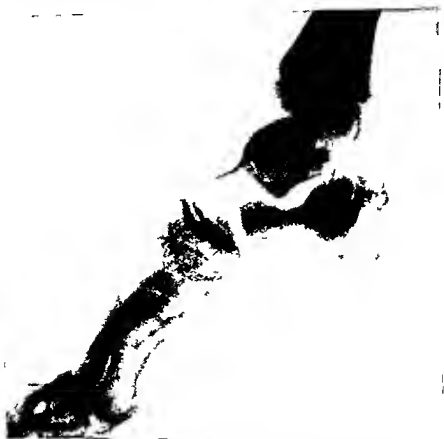


FIG. 565.—Tarsal scaphoiditis (Kohler's disease) (Boy 10 years old)

The outline of the condensed and compressed scaphoid is apparent

microscopical character is concerned, remains unknown, because an opportunity does not arise of obtaining fresh tissue, but so far as the X rays reveal it, the change is one of rarefaction of the outer portion of the bone, and a sclerosis of the interior.

CLINICAL FEATURES The disease is very rare after the sixth year. Limping, pain, tenderness, swelling and redness over the inner dorsal aspect of the foot are the usual signs of the disease.

X ray investigation shows an irregular blurred outline of the bone

¹ Pfahler and Hetzel *Surg Gynec and Obstet* 17, 625, 1913

with an increased density in the centre, the result of abnormal calcium content.

DIAGNOSIS. In many respects the disease closely resembles a tuberculous infection, but the infrequency of abscess formation, the localized nature of the disease, and the freedom of the surrounding joints are sufficient to distinguish Kohler's disease.



FIG. 566.—Tarsal scaphoiditis (Kohler's disease).
The hyper-calcification of the nucleus is evidenced by the dense shadow of the bone.

PROGNOSIS. It is a reassuring fact that even in the absence of active treatment a spontaneous recovery is made in about two years, and with suitable treatment the period is materially shortened. In no case has any serious persisting disability ever been recorded. The condition is said to predispose to the development of flatfoot in later life.

TREATMENT. Fixation of the part is the only necessity, and encasement of the foot in a light plaster splint for a period of six months is all that is required. At the end of this time the child is allowed to

go about, but it is advisable that the boot sole be raised on the inner side by $\frac{1}{2}$ inch in order to lessen the liability to flatfoot

CONGENITAL CLUB FOOT¹

DEFINITION Congenital club foot, *talipes equino varus*, *pied bot*, or *Klumpfuss* is a congenital deformity of the foot and leg, in which the foot is inverted and adducted, the heel is drawn up, and the leg rotated inwards. In its typical form the forepart of the foot is placed at right angles to the posterior portion, which in its turn is markedly



FIG 567—Double congenital *talipes equino varus* (Baby 3 months)

plantar flexed, forming almost a straight line with the long axis of the leg. This deformity accounts for 95 per cent of the congenital malformations of the foot, and is of considerable surgical importance.

ETIOLOGY

Little is known as to the real cause of this malformation, but there is no doubt that in a certain proportion of cases there is an hereditary factor, several generations of a family being affected, while the transmission of the fault may be through either the male or the female.

The condition is occasionally found associated with other primary deformities, such as harelip or cleft palate, and it occurs not infrequently as a secondary deformity in cases of spina bifida.

¹ The section dealing with Congenital Club Foot has been contributed by Miss Gertrude Herzfeld F.R.C.S.E. Surgeon to the Royal Hospital for Sick Children, Edinburgh.

When no other factor is at work, the deformity appears to be the result of a mal-position *in utero*, and is thought to be due to a deficiency in liquor amnii, thus allowing of undue pressure by the uterine wall on the limbs of the foetus. The presence of fibroid tumours in the uterus is also sometimes noted. Increased pressure is evidenced occasionally by the presence of marks or scars on the dorsum of the foot.

FREQUENCY

This deformity is relatively common compared with other congenital malformations and accounts for 95 per cent. of cases of congenital deformity of the foot. In the Royal Edinburgh Hospital



FIG. 568.—Congenital Contraction Deformities of both lower Extremities (Male baby 3 weeks old).

An error of the intra-uterine position was apparently responsible for the deformity.

for Sick Children during five years, 125 new cases of congenital club foot were seen in the Surgical Out-patient Department, representing 7 per cent. of the total new cases seen during that period.

In this series of 125 cases 90 occurred in males (= 72 per cent.), while females were affected in 35 cases (= 28 per cent.). The condition is stated to be more commonly bilateral than unilateral, but in the above series 62 were bilateral, and in 63 one limb only was affected. The left foot was involved twice as often as the right, the figures being, left 41, right 22

Table of Sex Distribution.

Males	90 = 72 per cent.
Females	35 = 28 „ „

Table of Side affected.

Left	41 = 34 per cent.
Right	22 = 17 „ „
Bilateral	62 = 49 „ „

PATHOLOGICAL ANATOMY

The typical deformity is a compound one, affecting not only the foot and ankle but also the leg. At the ankle joint the main deformity is one of marked plantar flexion with some inversion. The most obvious deformity, however, occurs at the mid tarsal joints, whereby the forepart of the foot is adducted almost to a right angle and inverted so that there is an extreme degree of supination of the foot. The inner border of the foot therefore is raised, shortened and bent on itself, while the outer border is convex and lengthened.

The leg below the knee is rotated inwards, there being a spiral twist of the tibia. This part of the deformity, often overlooked, accounts for the persistent in turning of the foot even after normal



FIG 569—Congenital Talipes equinovarus (Girl 5 years)

Extreme degrees of varus and adduction deformities exist



FIG 570—Congenital Talipes equinovarus (Baby 3 months old)

alignment of the foot and ankle have been secured. Some degree of rotation of the femur may also occur.

In early infancy the soft parts alone are affected, but if the case remains untreated, secondary bony deformities occur (in accordance with Wolff's Law) during the process of ossification and growth.

The changes in the soft structures consist of a shortening of muscles, tendons, and ligaments on the inner side of the foot with corresponding lengthening of those on the outer side.

The tendons of the tibialis anterior and posterior and the tendo Achilles are chiefly affected, being shortened and displaced

inwards; the displacement of the tendo Achilles tends to increase the



FIG. 571.—Right Congenital Talipes equino varus.

The persistence of the adduction deformity is well shown.

- (1) The shaft of the *tibia* is internally rotated at the junction of the middle and lower thirds.
- (2) The *astragalus* is plantar flexed and sub-luxated forwards with resulting broadening of the upper articular surface in its anterior portion, and this change sometimes accounts for the failure to secure complete dorsiflexion. Further, the head and neck of the astragalus are adducted and inverted.
- (3) The *os calcis* shows some plantar flexion, with inversion of the anterior portion, so that its inner surface is directed upwards. The bone instead of lying to the outer side of the astragalus is placed almost directly underneath it.

inversion of the sole. The inner half of the plantar fascia is thickened and shortened, while the internal lateral, astragaloscapoid, and calcaneoscapoid ligaments are similarly affected.

The skin on the dorsum and outer side of the foot is often thinner than normal at birth, but should walking be allowed and the deformity remains uncorrected, the weight-bearing portions of tissue undergo hypertrophy with the formation of bursæ and callosities.

The bony changes which occur in the untreated cases, and which become rapidly worse if weight-bearing is allowed, consist of the following:



FIG. 572 —Congenital Talipes

Boy aged 6 years suffering from untreated congenital talipes equino varus of the left foot. The child is walking on the outer and to some extent on the dorsal aspect of the foot.

The bone instead of lying to the outer side of the astragalus is placed almost directly underneath it.

- (4) The *scaphoid* is displaced inwards following the axis of the head of the astragalus and may actually articulate with the internal malleolus. It is usually smaller than normal.
- (5) The *cuboid* is correspondingly hypertrophied, and its axis is directed towards the middle line of the body. The other tarsal bones are displaced in accordance with the above noted changes, but are not independently affected. Frequently one sees a fan shaped spreading of the metatarsals.

CLINICAL FEATURES

The appearance of the foot at birth is character-



FIG 573.—Congenital Talipes
Double congenital talipes equino varus. A neglected case in a girl of 8 years.



FIG 574.—Congenital Talipes equino varus
(Girl 5 years)
The method of progression

istic. The forepart of the foot is placed at right angles to the axis of the leg, and in aggravated cases the great toe may almost touch the inner side of the tibia. A deep transverse crease is seen on the inner side of the foot opposite the mid-tarsal joint, while in many cases a vertical crease extends backwards from the under surface of the cleft between the first and second toes. The heel is small, ill formed, and drawn up, so that the normal prominence is lost.

The rigidity of the foot varies. Sometimes the deformity can be cor-

rected without force, but in the majority of cases there is marked fixation of the parts.



FIG. 575.—Double Congenital Talipes.

Equino varus deformity in right foot Calcaneo-valgus deformity in left foot

The foot as a rule is short and broad, and often the correction is difficult on account of this characteristic. Similarly, the fatter the child the more difficult the maintenance of the correction by splinting or plaster.

The leg as a whole is rotated outwards, and in some cases the patella is seen to be displaced slightly outwards.

DIAGNOSIS

The diagnosis as a rule is obvious, but it is always wise to examine for any evidence of spina bifida. One occasionally has difficulty in the older cases, where no history is obtainable, in diagnosing the congenital deformity from one acquired as a result of an infantile paralysis, affecting the peronei and the outer extensors of the toes, particularly as the muscles of the leg do not develop properly in untreated cases of club foot. The absence of any true paralysis and of the usual trophic changes confirm the diagnosis of congenital club foot.

PROGNOSIS

If untreated, the condition becomes worse, and with every month of life the treatment becomes more difficult. The untreated case is late in walking, and apart from the formation of callosities and corns the gait becomes clumsy and unsightly.

In early cases it is possible, with careful and prolonged treatment, to get a perfect anatomical and functional cure, but treatment is always prolonged and tedious, and both the surgeon and the



FIG. 576 —Double Congenital Talipes equino varus, with adduction of anterior tarsus (Boy 4 years).

patient's parents are apt to grudge the time necessary to achieve a satisfactory result in some of the more resistant cases. The age at which treatment is commenced bears a definite relation to the success of the individual case. On the whole, the delicate ill nourished child is easier to cure than the plump, active, and muscular infant.

TREATMENT

The first essential in the satisfactory treatment of this condition is to begin manipulation as early as possible. No infant should be left over for a week without active treatment being undertaken, for the earlier this is begun, the higher the percentage of perfect anatomical and functional cures.

In planning the method of treatment, we have three aims in view

- (1) Rectification of the shortened structures with over correction of the deformity
- (2) Maintenance of over correction while the internal structure is changing and particularly until such time as the child commences to walk
- (3) Repeated and constant supervision of the patient during the period of growth



FIG 577 — Congenital Talipes equino varus
This illustration indicates the adduction of the anterior tarsus which proves so difficult to correct

It must be borne in mind that in this condition, more perhaps than in any other congenital malformation, there is a persistent tendency to relapse, so that a foot which at the age of six months may appear anatomically perfect may, if not watched, present the appearance of an untreated deformity by the time the child is five years of age.

In order to ensure freedom from relapse it is important that by the time the child commences to walk the foot is well over corrected, so that the body weight tends to be a corrective to the inversion.

In planning the steps of the treatment we must consider the

correction of the various elements which go to produce the deformity in the following order :

- (1) The adduction and inversion at the midtarsal joint ;
- (2) The equinus deformity at the ankle joint ; and
- (3) The internal rotation of the leg below the knee.

A. TREATMENT OF INFANTS UNDER SIX MONTHS

When treatment is commenced before the age of six months it will be found that the best results are obtained by splinting rather than by manipulation, and the first object in view is the correction of adduction and inversion.

A light lateral splint of aluminium 4 to 8 inches long and 1 inch broad, covered with boracic lint, is applied to the outer side of the



FIG. 578.—Congenital Talipes equino varus.

Splints used in the correction of the deformity.

leg with adhesive plaster. The method of application of the splint is important, and should be carried out by the surgeon or by a specially trained nurse. At the first sitting all that should be attempted is a slight diminution in the degree of adduction, so that the splint is angled slightly inwards, just below the level of the ankle joint.

The splint should reach from $\frac{1}{2}$ inch beyond the small toe to the level of the head of the fibula, and two pieces of adhesive should be used to fix the splint in place. The first passes from the outer surface of the splint across the dorsum of the foot at the level of the metatarsophalangeal joints, encircles the foot twice, and is applied with the foot in the faulty position. The upper end of the splint is now brought in to the side of the leg, and in that way effects the necessary amount of correction of the foot itself, and the second piece of adhesive is strapped around the upper third of the leg. A light bandage completes the splinting.

The splint at first should be changed every five to seven days,

and on each occasion the position of the foot is improved by changing the angling of the splint, until the foot lies in a position of marked abduction. This process may take from two to four months, and it is important that before proceeding to the next step the foot should remain over corrected even though the splint is left off for two or three days. When this is achieved, it will be found that the foot has become practically normal in appearance, with disappearance of the transverse crease, while the tendo Achilles, from being displaced inwards will be found to have taken up its normal position.



FIG 579—Congenital Talipes equino varus
Lateral splint applied for correction of the deformity

At this stage manipulation of the almost flaccid foot under an



FIG 580—Congenital Talipes equino varus
Correction of the adduction by manipulation on an orthopedic wedge

anæsthetic may be carried out to make sure of undoing any possible

contraction of the plantar fascia, and if the tendo Achilles, which has hitherto not been stretched in any way, is still taut, a sub-cutaneous tenotomy should now be carried out, and the foot put in plaster of



FIG. 581.—Congenital Talipes equino varus.

The deformity has been corrected by manipulation and a plaster case has been applied. Note that the case extends from the mid thigh to the toes.

Paris in a position of over-correction, externally rotated, and with the knee flexed, as shown in Fig. 581. It is important to carry the plaster to the middle of the thigh with the knee flexed almost to a right angle, as the eversion and abduction of the foot is thus maintained by the reverse leverage of the thigh. The plaster should remain in place for three or four weeks, when the process should be repeated.

with the result that in a few months' time the deformity will be found to have relapsed. During the second half of the first year, over-correction must be maintained, either by the use of Jones's talipes splints or by the repeated application of plaster. By the time the child is a year old and is anxious to put his feet to the ground, the deformity should have disappeared.

Early walking should be encouraged, but as a matter of fact many of these patients are late in walking. The baby should not be allowed to walk in bare feet, and the boots, which should be light, should have the soles thickened slightly on the outer side. It is also advantageous for the child to wear a splint at night to maintain over-correction.

Thus, by the time the child is about six months old, there should be practically no sign of the deformity. It is at this stage that the parents, believing the condition to be entirely cured, are apt to cease attending for treatment,

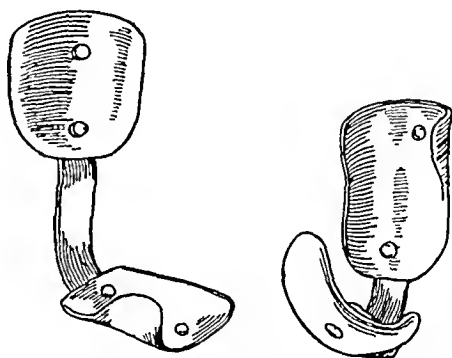


FIG. 582.—Talipes Shoes.

During the next year the child should be seen at least once a month, and if there is the slightest sign of relapse the foot should be again over corrected and a retaining plaster applied. In the majority of cases it will be found that this has to be repeated on one or two occasions.

As soon as the child is old enough he should be trained to walk with the foot well everted, and during the third year simple exercises may be tried.

It is often between the ages of two and three that the tendency to relapse is most persistent, and in such cases it may be necessary to resort to the application of a lateral iron, in order to maintain correction while walking.

The internal rotation of the leg should be slightly corrected every time the child is put into plaster, but great care must be taken not to



FIG. 583.—Congenital Talipes

Thomas wrench and orthopaedic wedge used in the correction of the error

produce a condition of knock knee, as the correction of the rotation may cause stretching of the internal lateral ligament.

The parents should be warned to return the moment there is the slightest sign of any deformity, as the correction is easily carried out up to the age of six or seven years by the application of plaster for one or two months.

It will be noted that with the exception of the tenotomy of the tendo Achilles, no manipulative or operative procedure has really been required, but if the condition recurs in later childhood forcible correction is necessary, and should be frequently repeated whenever the slightest deformity reappears.

B TREATMENT IN OLDER INFANTS AND YOUNG CHILDREN

In such cases gradual correction by splinting is not satisfactory, and it is preferable to manipulate the foot vigorously under an anæsthetic, using the Jones' wedge and the Thomas' wrench followed

by plaster fixation, and it will be necessary to repeat the forcible correction, at intervals of about six weeks, some four or five times;



FIG. 584.—Congenital Talipes equino varus.
The method of application of the Thomas wrench

otherwise the treatment is much the same as for the early cases.
It cannot be too strongly emphasized that success can only be

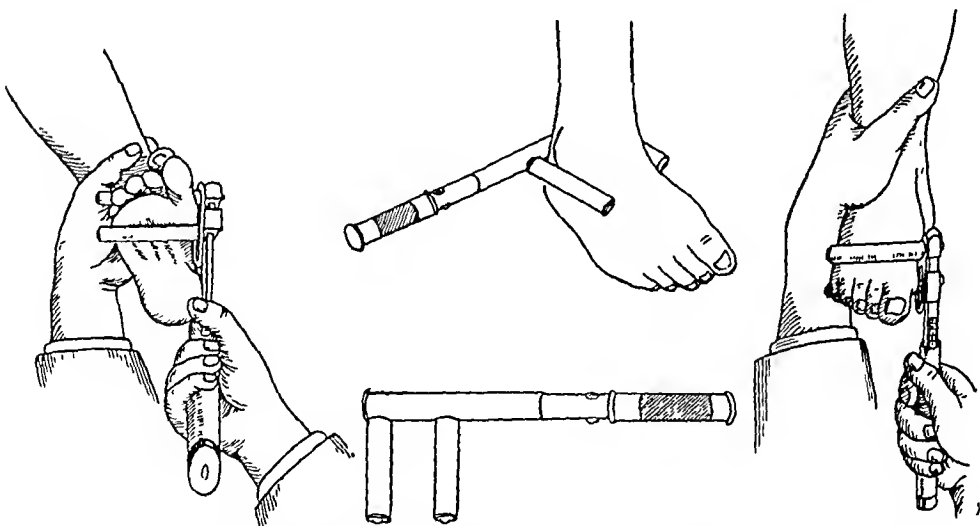


FIG. 585.—The Thomas Wrench as used in the treatment of Club Foot and certain stages in its application. (*Whitman.*)

obtained by repeated and continuous treatment, and the parents should be impressed with the necessity of attending frequently and over many months.

In a child who has been treated before the age of five or six years bone operations and other open operations should never be required, and the necessity for such operations in later life in patients who have been treated in infancy reflects on the skill of the surgeon who was responsible for the original treatment.

Occasionally, however, where the rotation of the tibia is unduly marked, it will be found that even after the foot is well corrected the child walks with the foot turned in. It may then be necessary to perform an osteotomy of the tibia in order to swing



FIG 586—Removal of a wedge from the greater process of the os calcis for correction of the adduction deformity of congenital talipes equino varus



FIG 587—Polydactylism

The right foot carries seven toes three digits occupying the position of the fifth toe

out the foot at the junction of the middle and lower thirds of the leg. This should not be done before the age of four.

Open Operations

These should never be performed before the age of six years, and the necessity for such operations denotes failure of treatment during infancy.

A. OPERATIONS ON LIGAMENTS

Ober's Operation. A curved incision is made around the internal malleolus. The deltoid ligament is detached transversely off the tibia, and it and the inferior calcaneo-scaphoid ligaments are separated off the inner surface of the *os calcis*. The foot is then manipulated, thus opening up the inner side, and when over-correction has been secured plaster is applied after suturing the skin.



FIG. 588.—Polydactylism.

The great toe is duplicated in the left foot and the little toe in the right foot.

B. OPERATIONS ON LIGAMENTS COMBINED WITH OSTEOTOMY

Elmslie's Operation. This consists in the division of the internal lateral ligament, combined with the removal of the astragalo-scaphoid and calcaneo-scaphoid capsules. The tibialis posticus is divided and the operation completed by a transverse osteotomy of the *os calcis*.

C. BONE OPERATIONS

Hoke's Operation. Hoke's operation consists of a series of operations on the tarsal and metatarsal bones, including when necessary the *os calcis*, the head and neck of the *astragalus*, the *internal cuneiform*, the *cuboid*, and the posterior ends of the metatarsals.

Albee's Operation. This operation is best performed in the long and slender type of club foot, and consists of the removal of a wedge of *cuboid*, which is then inserted into the split *scaphoid*, the object being to shorten the outer side of the foot, and at the same time lengthen the inner.



FIG 389 — Polydactylism

Additional great toes in both feet. The X ray appearances afford interesting contrasts.

Other Varieties of Congenital Talipes

Other varieties of congenital talipes are met with in addition to the equinovarus type

Congenital talipes varus is moderately common. It is usually slight in degree, and in many instances it is accompanied by a hallux varus condition of the great toe and a pigeon-toed gait. The slighter examples of the error yield to manipulation, more severe cases require wrenching and the application of a plaster case.

Congenital talipes valgus is also a comparatively common error, mild degrees of the deformity constitute what is known as 'weak ankle'. The condition is overcome by repeated manipulation, and when the child begins to walk, heightening the boot sole to the inner side will afford further benefit.

Congenital talipes equinus is very rare, at least in so far as the pure examples of the displacement are concerned. Manipulation, mechanical correction, or tenotomy are the means by which the error is overcome.

Congenital talipes calcaneus is also rare. The heel is prominent, the foot is dorsiflexed so that the dorsum comes into contact with the front of the tibia, and the foot sole is flattened, this point being in striking contrast to the cavus condition of the acquired variety. The error is often accompanied by a genu recurvatum, and malposition *in utero* is an evident cause of the deformity.

As a rule the deformity is slight, so that it yields to massage and manipulation. The retention of the foot in a position of plantar flexion will hasten the improvement.

A backward bending of the tibia sometimes accompanies the foot error. Various combinations of the above error, such as calcaneo valgus, calcaneo varus, equino cavus, valgo cavus, and pure cavus are occasionally met with.



FIG. 590.—Double Congenital Talipes calcaneus (Baby 2 months old).

CERTAIN RARE DEVELOPMENTAL ERRORS

Additional Limb (Polymely). We have seen two examples of this condition, and one is figured. A well-formed limb developed from the region of the perineum, and at the time of birth had reached



FIG. 591.—Malformation of Lower Lumbs.

Baby born with three legs An imperfect leg is growing from the perineum

a stage of growth almost as complete and perfect as the normal limb. The distal skeleton of the additional limb was healthy, but the upper

end of the femur was imperfect and no articulation with the pelvis existed. The development resulted in the displacement of the anal canal to one side of the perineal field.

The condition is so rare that it is of little practical interest. If the child is viable and otherwise healthy, amputation is indicated.



FIG. 512.—Congenital shortening of left femur (Baby 3 months old).
There is no evidence of intra uterine bone injury. Possibly the blood supply is congenitally deficient.

Congenital Absence of the Fibula The characters of this deformity are striking. The limb is atrophied, especially below the knee, and there is a considerable degree of shortening. The tibia is curved at the junction of the lower and middle thirds, the angle being usually directed forwards and inwards, so that the foot is thrown into a valgus position. A cicatrix may exist at the summit of the curve.



FIG. 593.—Congenital Malformation of left Leg (Girl 2 years old).

The limb is a deformed appendage attached to the lateral wall of the pelvis; there is no proper hip joint.

The fibula is either entirely absent or exists as a remnant representing the upper extremity of the bone. There is an associated absence of one or more toes on the side corresponding to the fibular derangement, and certain of the tarsal bones may be absent or fused together. The origin of the condition is doubtful; intra-uterine pressure probably exerts some influence.

Treatment is a difficult problem. Correction of the tibial deformity and the insertion of a graft to replace the deficient fibula may be successful. If this fails, the child may be supplied with some variety of prosthetic apparatus, or the limb may be amputated.

Congenital Absence of the Tibia.

This is a much rarer deformity than the corresponding condition of the fibula. The tibia is

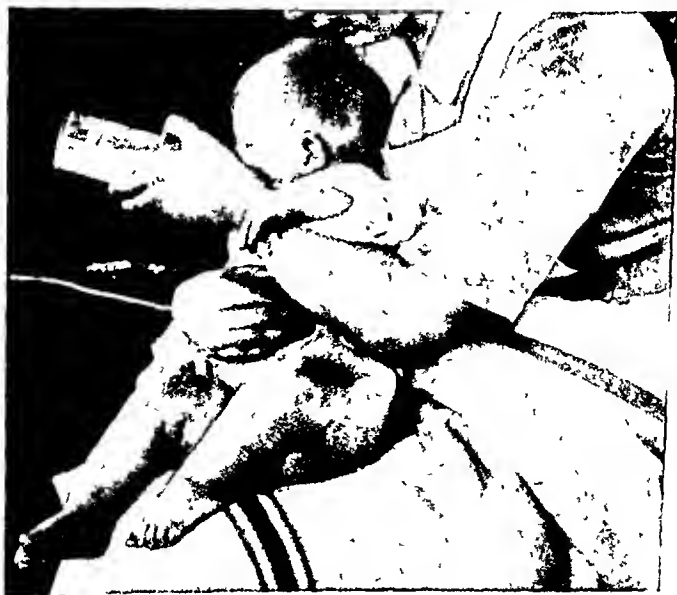


FIG. 594.—Congenital Deformity and Shortening of the shaft of the left Femur.
The condition has probably been the result of an intra-uterine fracture.

either entirely deficient or is represented by a small segment of the upper end of the bone. The fibula is generally increased in size, while the lower end is bent inwards. The lower end of the femur is usually deformed in a curious fork like arrangement, and in one case which we observed the patella was absent. On account of the femoral distortion there is inability to completely extend the knee. The deformed position of the foot is, of course, a very obvious feature.

The principles governing treatment are similar to those described in connection with the fibular error.



FIG 595—Congenital absence of Fibula in right Leg

The two outer toes are absent in the right foot

Congenital Genu Recurvatum Examples of this rare deformity are occasionally met with. The child is born with a hyperextension of varying degree in one or both knees. The joint is not fixed, and the deformity may be diminished or exaggerated at the will of the examiner. The skin covering the front of the knee is traversed by deep creases, while the coverings of the posterior aspect are tense. The ligaments on the anterior aspect of the joint are relaxed, but the quadriceps tendon is taut, and one is left with the impression that this structure is responsible for the persistence of the deformity.



FIG. 593.—Congenital Malformation of left Leg (Girl 2 years old).

The limb is a deformed appendage attached to the lateral wall of the pelvis, there is no proper hip joint.

The fibula is either entirely absent or exists as a remnant representing the upper extremity of the bone. There is an associated absence of one or more toes on the side corresponding to the fibular derangement, and certain of the tarsal bones may be absent or fused together. The origin of the condition is doubtful; intra-uterine pressure probably exerts some influence.

Treatment is a difficult problem. Correction of the tibial deformity and the insertion of a graft to replace the deficient fibula may be successful. If this fails, the child may be supplied with some variety of prosthetic apparatus, or the limb may be amputated.

Congenital Absence of the Tibia. This is a much rarer deformity than the corresponding condition of the fibula. The tibia is



FIG. 594.—Congenital Deformity and Shortening of the shaft of the left Femur. The condition has probably been the result of an intra-uterine fracture.

congenital errors, such as congenital knock knee, congenital genu varum, and congenital dislocation of the hips.

Treatment includes massage of the wasted and shortened muscles and forcible manipulation into a position of flexion. The more extreme type of case will probably demand exposure and lengthening of the shortened structures, more particularly of the quadriceps extensor or of the ligamentum patellæ.

Congenital Flexion Contraction of the Knee is sometimes met with. It is a troublesome deformity necessitating open division of the contracted tissues.



FIG. 597.—Congenital Genu recurvatum (Baby 6 months old)

Congenital Abnormalities of the Patella *Congenital absence of the patella* is actually a very rare event, many cases thought to belong to this class are really examples of rudimentary patellæ, the nuclei developing as the child grows. Any congenital defect which involves the quadriceps extensor muscle is likely to be associated with patellar derangement.

Massage and stimulation of the affected muscles and restoration of movement to the part may improve the development of the bone.

Congenital displacement of the patella may occur. Lateral displacement is the most frequent, but the bone is displaced upwards,

On the other hand, the soft structures at the back of the knee are uniformly tense. The patella is small and may be almost unrecognizable, but a nucleus probably always exists ; the posterior surfaces of the femoral condyles and the head of the tibia form a marked prominence in the region of the popliteal space.

While voluntary flexion is impossible, passive flexion can be carried out, but it is characteristic of the condition that when the limb is liberated it flies back like a spring to its original position.



FIG. 596.—Congenital Absence of Tibia (right Leg)
(Baby 8 months old).

The condition is not one of congenital dislocation, as is sometimes stated, for the articular surfaces remain in full contact with each other. We have definite evidence that an abnormal intra-uterine position, combined, it may be, with a diminished amount of liquor amnii, are the influences at work in the origin of the deformity. The majority of these cases are born as breech presentations, and an over-extension of the limb is apparently maintained from an early stage of foetal life. The condition is often accompanied by other

APPENDIX

METHOD OF MAKING CELLULOID SPLINTS

The first and most important part in the process of making celluloid splints is to obtain a very accurate mould of the limb in plaster of Paris. The comfort and fit of the splint depend entirely on the accuracy of the cast.

The Plaster Mould

Required

- 1 Vaseline and vaseline bandages
- 2 A good supply of plaster bandages
- 3 A strip of lead about 1 inch wide
- 4 A sharp knife scissors and a tape measure

Vaseline bandages are made by dipping strips 2 to 3 inches wide of fine muslin or nainsook in hot liquid vaseline, melted in a small basin placed in a pan of hot water over a gas ring. The strips must be well squeezed out and wound round a piece of cardboard ready for use. The ends should be folded together to facilitate unwinding.

Plaster bandages are made of lengths of crinolene muslin 2 to 4 inches wide and from 50 to 72 inches long. The selvages and loose threads should be removed.

Place the bandage in the lid of a box, and scatter dry plaster of Paris evenly over it. Roll up loosely from one end. Wrap each bandage when completed in thin paper, and place in a tin box ready for use. The plaster should be kept in an airtight tin, such as a bread pan and in a dry place.

Making the Mould

A Leg Case

Rub the limb over with vaseline to prevent hairs being caught in the plaster, and to facilitate removal of the plaster mould. Where the hairs are thick or long and do not smooth down, cover with vaseline bandage.

Place the strip of lead down the front of the leg and nearly to the end of the toes, bending it to follow the curves. Meantime the assistant should have placed two plaster bandages in a basin of tepid water, with the ends over the edge of the basin to facilitate unwinding. When one bandage is taken out another should be put in the basin.

Squeeze out the superfluous water and bandage the limb quickly and evenly, keeping the lead in position. Do not fold the bandage, rather cut it off and start again. Smooth it down with the hands and apply others as quickly as possible till there is a sufficient even thickness all over to make a firm mould.

While the plaster is still pliable, correct the position of the foot which should also be attended to during the bandaging.

in genu recurvatum for example, and in certain cases a downwards or an inwards displacement has been described. The lateral displacement is practically always accompanied by some degree of knock-knee.

Treatment entails the correction of any related deformity and the division of shortened structures, so that the patella may assume its correct position.

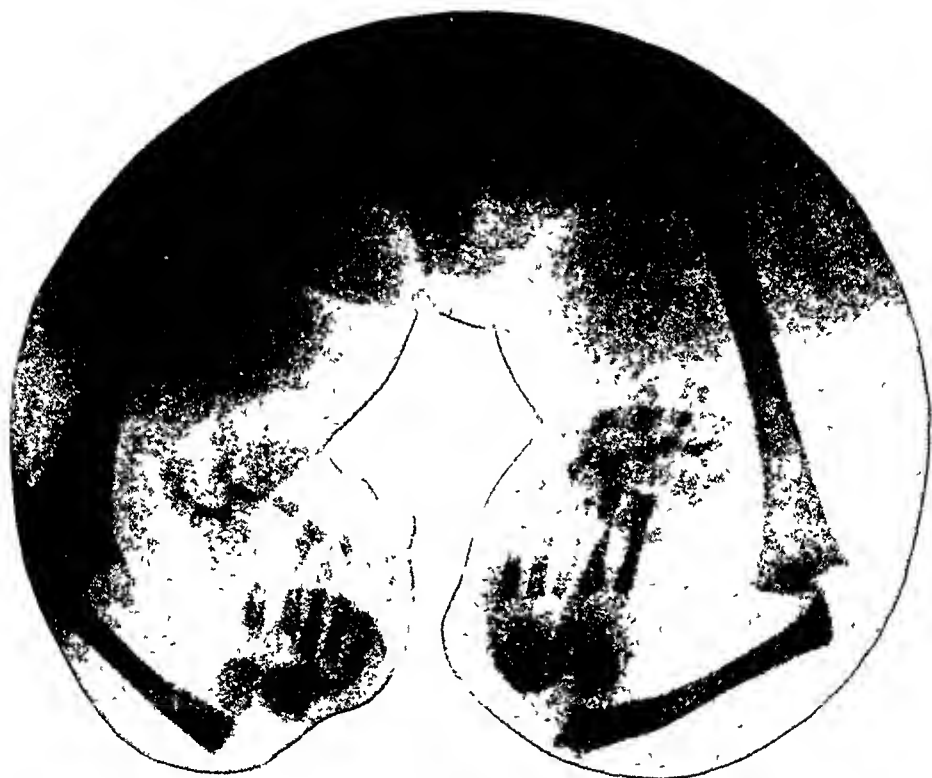


FIG. 598.—Congenital Malformation of Extremities (Child 10 months old).

The patellæ and the fibulæ are absent, while both feet are in an exaggerated talipes equinovarus attitude.

Slipping patella is sometimes met with in children. Slight cases respond well to fixation of the part by a plaster bandage or a knee-cap; more extreme examples demand an operation similar to that employed in the adult.

Congenital elongation of the ligamentum patellæ has been described by Shaffer, and we have seen several examples of the disorder. The wearing of a brace was sufficient to control the disability. The condition of snapping knee was an accompaniment in one of these cases.

making it quite smooth, and enlarging the cast about $\frac{1}{2}$ inch in circumference all over, to make the splint large enough to enable a thick stocking to be worn under it. Any part, such as the ankle, where pressure would be painful, should be considerably enlarged, also at the sides of the heel. Care must be taken to retain the correct form and proportion.

For children it is well to make the foot from $\frac{1}{2}$ inch to 1 inch longer to allow for growing.

When the cast is thoroughly dry, a thin coating of wax is applied to prevent the splint adhering to the cast when finished. Special paraffin wax melting point 114 degrees Fahrenheit, should be used, the wax being heated in a pan or fish kettle, over a gas ring. When the wax is very hot and the cast is also hot hold the cast by one end over a tray or tin with an edge and pour the wax over the cast as quickly as possible, so as to form a thin even coat. The superfluous wax may be poured back into the pan and used again. If the pan is large enough the cast can be dipped into it. Rough pieces of wax should be scraped away with a graving tool.

Making the Splint

Required

Brushes. (Different brushes should be used for glue, Pexuloid, and Pexuloid varnish. Black varnish brushes, $1\frac{1}{2}$ inches are best for glue and Pexuloid, and 1 inch oil paint brushes for Pexuloid varnish. The Pexuloid brushes must be cleaned in acetone when used and the glue brushes in soap and water.) Scissors. Bandage mushin. Boot hooks and eyelets. A hand drill to make the holes. A hand punch to put in the hooks and eyelets. Pexuloid and Pexuloid varnish. Certus cold glue powder.

To make Certus Glue. Place a large spoonful of the powder in a basin and hold it under a tap of cold water which just drips. Stir it vigorously in the centre keeping it smooth and very gradually working the powder in, regulate the water continue stirring until all the powder has been mixed in and the solution is smooth and fairly thick. It is best to prepare fresh solution for each occasion.

To make Celluloid Solution. Required 1 oz celluloid cuttings 11 oz acetone 5 dr amyl acetate. Put the celluloid into a bottle pour about half the quantity of acetone on it add the amyl acetate diluted with some acetone then add the remainder of the acetone. Cork securely. Turn the bottle every day. When completely dissolved it is ready for use. It takes about one month or longer to dissolve.

Pexuloid is a trade name for celluloid solution. It differs slightly from the above mixture. It can be obtained from Messrs. Thos. Morson & Son Ltd. 47 Gray's Inn Road London both as Pexuloid solution and Pexuloid varnish.

Method. The cast is fixed firmly in a vice.

Cut fifteen pieces of bandage mushin to size or sixteen if the splint is to be made extra strong. One piece (the last to be applied) should be cut $\frac{1}{2}$ inch larger. Paint the cast over with Pexuloid and put on the first mushin coat at once while wet. Brush it over with Pexuloid cutting the mushin to shape as you work. The coats should overlap slightly everywhere, but superfluous mushin must be cut away. It must be quite smooth with no wrinkles.

Mark lines across the front of the case with an indelible pencil in three places to enable the mould to be correctly joined again. Cut the plaster down the centre of the lead to within about 2 inches of the end of the toes before the plaster hardens. Do not remove it till it has hardened sufficiently to retain the shape.

The mould must now be opened out sufficiently to enable the limb to be removed, but this must be done gently without disturbing the impression. Thereafter press the mould together again so that the pencil marks are apposed, and correct any disturbance of the position. Thereafter bandage with a plaster bandage till the case is firmly joined.

Measurements should be taken with a tape measure round the top of the leg, where the cast ends, round the calf, ankle, heel, instep, and the length of the foot. Also place the foot on a sheet of paper and trace an outline of it.

Filling the Mould

Required :

1. Liquid soft soap.
2. Plaster of Paris.
3. A 6- to 8-inch length of square $\frac{1}{2}$ -inch iron or a similar length of 1-inch square wood.
4. A wire hook, knife, brush, spoon, basin, etc.

Liquid Soap is made by melting a tablespoonful of soft soap in 10 oz. boiling water, stir in a pan till melted, when cool pour into a bottle or jar for future use.

METHOD. Brush out any loose pieces of plaster. Pour some of the liquid soap into the mould, turning it about and pouring out and brushing it till it is all coated with the soap. Drain out any superfluous fluid while the plaster is being mixed.

About 1 pint of water is sufficient for a child's leg. Scatter the plaster into the water with the hands as quickly as possible, avoiding lumps; when it begins to lie on the surface of the water stir vigorously with a spoon placed flat in the basin.

While it is still fairly liquid pour some into and out of the mould, as was done with the soap, till it is quite coated all over. Add a little more plaster till it is cream-colour, stirring vigorously; it is the right consistency when it begins to bubble, and must be quite smooth. Pour it into the mould, shaking it well into the foot, then fill up to the top. Before it hardens, insert a hook at the edge, and an iron rod in the centre, allowing the latter to protrude about 3 inches; this is used to fix into the vice to hold the cast steady. To the hook should be attached a label with details of the case, but this should not be tied on before waxing, as it is apt to be coated with wax and rendered illegible.

FINISHING THE CAST. When the plaster is sufficiently hard, cut down the original join with a sharp knife, and press the sides of the mould back. Cut it away at the foot, and at the ankle, so that the mould may be taken out easily, lest it should break. The mould is of no further use. If the cast is dry it should be wetted before building it up, and if it has been left a day before finishing, soak it in water for some time before beginning work on it. Any rough parts may be scraped away with a graving tool. Fresh plaster should be mixed and applied with the hand,

INDEX

- Abbot's corrective jacket for scoliosis 735
- Abdomen, examination of 9
 by palpation 10
 by percussion 10
 lower burns of severe 20
 non-inflammatory conditions de
 cubitus in 5
 palpation of in examination for
 appendicitis 827
 surgery of 791
 tuberculosis of, surgical aspects of
 809
- Abdominal wall inversion of in treat-
 ment of umbilical hernia, 778
 tumours of 791
- Abduction splint in shoulder joint
 tuberculosis 439
- Abscess Brodie's, as complication of
 osteomyelitis 240
 cervical in Potts disease 286
 cold, examination for in Potts
 disease, 301
 formation of in Potts disease
 286 320
 sites of 321
 treatment of 321
 in tuberculous cervical adenitis
 646
 treatment of by aspiration and
 injection 276
 by incision with drainage 278
 by simple aspiration 276
 conservative 276
 dorsal in Potts disease 287
 sites of 288
 formation of as symptom of Potts
 disease 293
 in 'bone tuberculosis 262
 ischio rectal 883
 lumbar in Potts disease sites of
 289
 mammary 672
 pancreatic 867
 perianal 883
 peritonsillar 586 588
 retropharyngeal 564
 in Potts disease 287
 recurrent as complication of osteo-
 myelitis 240
 secondary formation of as post
 operative complication of ap-
 pendicitis, 838
- Acetabulum, wandering 397
- Acetonæmia, anaesthesia contra indi-
 cated in 70
 treatment of, 70
- Acetonuria anaesthesia contra indi-
 cated in 70
- Achondroplasia, 351
 clinical features of 352
 diagnosis of 353
 etiology of 351
 pathology of, 351
 prognosis of 354
 treatment of, 354
 Trident's, hand in 353
- Acidosis influence of in etiology of
 rickets 88
- Aerocephaly 463
- Adenitis, acute and hip joint tuber-
 culosis differential diagnosis
 of, 407
 cervical tuberculous 628
 age incidence in 628
 and sub acute differential diag-
 nosis of 637
 changes in individual glands in
 632
 clinical features of 635
 diagnosis of 637
 etiology of 628
 predisposing infections in 630
 prognosis of 639
 recurrence after operation 646
 routes of infection in 629
 treatment of conservative 640
 general 640
 local 641
 operative 642
 complications during 646
 contra indications of 643
 type of bacillus in 629
 types of 635
 chronic, simple and tuberculous
 differential diagnosis of 638
 sub acute and tuberculous differ-
 ential diagnosis of, 637
- Adeno myo sarcoma (embryomata) of
 kidney 894
 clinical features 896
 diagnosis 897
 pathology 894
 treatment 897
- Adenoid facies 585
- Adenoids 585

The second coat is applied in the same way with Pexuloid. Leave it to dry for twenty-four hours, then put on nine coats of muslin, using Certus glue instead of Pexuloid: this should be applied fairly thick and brushed firmly on. Then brush the sole with Certus glue, and apply a thin leather sole, cut the exact size, which must lie quite flat, brush it over and apply a muslin sole cut slightly larger than the leather one to keep it firmly in position. Then put on two more whole coats of muslin with Certus glue. Leave it till quite dry. The joins in the muslin should not always be in the same place, or it would make a ridge; they should be varied. Mark faintly with a pencil down each side of the leg and foot where it is to be cut, and cut it with a very sharp knife down the lines indicated. Remove it from the cast, and knock out any plaster or wax which has adhered to it.

Cut it neat with curved scissors, and sandpaper it on the surface and at the edges.

Put on one coat of muslin with Pexuloid, and turn the edges of the last coat (which was cut larger) over to the inside to make a binding.

When quite dry apply two coats of Pexuloid varnish with a brush.

Drill holes at intervals of about 1 inch apart down each side, making the holes correspond on the two sides. Insert eyelets to the inside of the leg, and boot-hooks to the outside.

Cover the inside of the hooks with a strip of muslin applied with varnish.

Lace up, and it is ready for use.

The side with the eyelets should not be unlaced when put on; just slacken the lace to enable the leg to be inserted. The side with hooks can easily be laced. The reason for eyelets being used to the inside is to prevent scratching the other leg.

All through this work great care has to be taken not to drag the muslin too tight so as to cause an air bubble. Should a small bubble be found, it can be slit, and when firmly pressed down so that the air is excluded, a small piece of muslin can be pasted over the slit. In the case of a large bubble, it is best to cut the piece out and make it up again with small pieces cut to the exact size of the hole, keeping it as smooth as possible.

Spinal Supports. In the case of a spinal support, the whole process is similar, but wider and longer plaster bandages should be used in making the mould. In filling the mould, after there is a coat of about an inch all over, some scrim or sacking can be soaked in plaster and laid on; it ensures a firm cast, and saves plaster. It is not necessary to make the cast solid, just thick enough to make it firm. It should be made flat at the base so as to stand firmly, as it is too heavy to fix in a vice, though it is possible to do so by fixing a piece of wood in the vice, with a cross-bar on it to prevent the cast from slipping down. This can only be done if the cast is not solid.

The jacket may be fitted with straps and buckles, or boot-hooks and laces. Fasten it down the left side and shoulder.

These splints are extremely light and rigid, and are invaluable when these two conditions are required. They can be washed oven with hot water without altering the shape or softening them.

When necessary, they can be strengthened with aluminium bands, which are inserted between the fourth and fifth layers of Certus muslin, or riveted on after the splint is finished. The aluminium must be moulded to the contour of the limb.

- Anus, fissure of, symptoms 877
treatment 878
imperforate varieties of, 871
- Appendicitis, 823
age incidence of 823 824
and hip joint tuberculosis differen-
tial diagnosis of 409
chronic 839
clinical evidences of, summary, 828
features 825
complications of post operative, 838
diagnosis of 831
differential diagnosis of 831
etiology of, 823 825
examination of physical, 826
pathology of, 825
prognosis of age incidence in 834
simple treatment of, operative 835
symptoms of 826
treatment of 835
operative 835
after treatment 837
closed method in, 837
when operation contra indicated
835
types of infection of 834
with peritonitis treatment of, opera-
tive, 836
with abscess treatment of opera-
tive, 836
- Appendix anatomy of, 823
iliac left 830
locality of special features dependent
on 829
mesenteric 830
pelvic 829
position of, influence of in appendi-
citis 834
recto caecal 829
sub hepatic or high 830
- Appliances ambulatory types of in
treatment of infantile para-
lysis 957
- Arachnodactyly 1078
- Arm (see Extremity, upper)
- Arteries, carotid, ligature of, in treat-
ment of extra ventricular
hydrocephalus 507
- Lexers, 215
- Arthritis 363 (see also Synovitis
acute infective)
acute and hip joint tuberculosis
differential diagnosis of 407
as post-operative complication of
osteomyelitis 232
- Deformans 450
etiology of 456
pathology of 456
proliferative diagnosis of 457
etiology of 456
prognosis of 457
treatment of 457
local 458
infective acute of infants 368
- Arthritis, infective, as complication of
infectious diseases 368
spondyl tuberculous pathology of
290
- Arthrodesis in flat joints 965
- Arthrotomy for acute infective syno-
vitis of elbow joint 373
for synovitis of ankle joint 373
of shoulder joint 372
- Artificial light in surgical tuberculosis,
115 116
- Ascites tuberculous treatment of by
casiotomy 811
- Aspiration and injection treatment of
cold abscess, 276
treatment of cold abscess, 276
- Asthma neonatorum in goitre 659
- Astragalo navicular disease 437
- Astragalus subluxation of congenital,
1072 1073
- Athyrosis congenita 354
- Atlas, ankylosis of with occipital
bone 691
- Atresia of lower end of rectum 874
- Atrophy in diagnosis of elbow joint
tuberculosis 443
- Atropin administration of in hypoder-
mic injection 75
dosage for, at different ages,
75
- Auricle accessory 526
congenital absence of 568
malformation of 569
supernumerary 569
- Auscultation, in chest examination of
10
- Auto intoxication from intestinal canal
in etiology of rickets, 87
- B I P paste for mastoid operations,
composition of 581
- Babies examination of 2
- Back acute inflammatory conditions of
decubitus in 5
- Balance, education in in spastic para-
lysis 979
- Bandage and sling in shoulder joint
tuberculosis 439
hyperflexion, in fracture of elbow
167
plaster in ankle joint tuberculosis
433
in knee joint tuberculosis 426
in rachitic knock knee 1058
- Barrel stave splint Roystons in
fracture of clavicle 145
- Bat ear 569
- Bayliss's gum saline solution in treat-
ment of surgical shock 41
- Beck's paste in operative treatment of
bone tuberculosis 274
solution for treatment of tuberculous
sinuses 279

- Adenoids, clinical features of, 585
 diagnosis and treatment, 586
 in etiology of tuberculous cervical
 adenitis, 629
 infected and middle-ear inflamma-
 tion, relationship of, 572
- Adenomata, foetal, of thyroid gland,
 660
- Adhesions in empyema, diagnosis of,
 by estimation of intra-pleural
 tension, 681
 X-ray diagnosis of, 681
- Adrenals, small, in osteogenesis im-
 perfecta, 137
- Air, fresh, in prophylaxis of rickets, 97
 injection of, in treatment of intussus-
 ception, 847
 passages, operations on, 599
 intubation, 599
 surgery of, 593
- Albee's operation for congenital club-
 foot, 1100
 for Potts' disease, 319
- Alcohol treatment of burns and
 scalds, 26
- Alkalis to diminish risk of surgical
 shock, 36
- Aluminium aniline preparations in
 treatment of burns and scalds,
 26
- Ambrin and paraffin applications in
 treatment of burns and scalds,
 26
- Amputation, congenital, 985
- Anæmia as indication for transfusion
 and infusion, 54
 blood-transfusion in, value of, 460
 splenic, splenectomy in, value of, 460
 treatment of, operative, 868
- Anæsthesia, 74
 and surgical shock, 37
 blood pressure readings during,
 value of, 80
 conditions governing postponement,
 75
 co-operation between anæsthetist
 and surgeon, 74
 in abdominal examination, 10
 local, 79
 preparation for, enema in, composi-
 tion of, 75
 morphia in, danger of, 75
 nutriment during, 75
 purgatives, danger of, 75
 special precautions in, urine, ex-
 amination in, 76
 starvation in, dangers of, 75
 water during, 75
 spinal, 79
 stage of recovery from, 80
 opiate to relieve pain, composi-
 tion of, 81
- Anæsthetic, administration of, points
 in technique of, 79
- Anæsthetic, before treatment of frac-
 tured clavicle, 140
 choice of, chloroform, advantages
 and disadvantages of, 78
 ether, advantages and disadvan-
 tages of, 77
 ethyl chloride, advantages and
 disadvantages of, 79
 gas and oxygen, value of, 78
 in reduction of displacement in
 fracture of shaft of humerus,
 153
 odour of, vapours used to disguise,
 79
- Anal canal, congenital narrowing of,
 treatment of, 870
- Anatomical abnormalities and Potts'
 disease, differential diagnosis
 of, 304
- Ankle-joint, acute infective synovitis
 of, 372
 deformities of, in paralysis, 960
 fractures around, 204
 tuberculosis of, 431
 deformity in, correction of, by
 plaster bandage, 433
 by reduction, 433
 diagnosis of, 432
 differential diagnosis of, 432
 pathology of, 431
 prognosis of, 433
 signs of, 432
 symptoms of, 431
 treatment of, 433
 by Bier's congestive method,
 434
 by complete functional rest,
 appliances for, 434
 by injection, 434
 operative, after-treatment, 436
 technique of, 435
 pain in, by extension, 433
- Anoxæmia, dangers of, 77
- Antero-posterior splint for Colles frac-
 ture, 181
- Antigen therapy in tuberculosis, 117
- Antiseptics, depot, composition of, 14
 varieties of, 14
- Antitetanic serum in severe wounds,
 value of, 12
- Antrum, mastoid, infections of, 576
- Anus, abnormal position of, 872
 treatment of, 872
 congenital absence of, 872
 treatment of, 873
 errors of, 869
 malformations of, 870
 occlusion of, by membranes or
 bands, 871
 treatment of, 871
 development of, 869
 diseases of, 869
 fissure of, 877
 examination, 878

Bone and Bones

- affections of in congenital syphilis 127
- anatomy of 213 214
- anomalies of 987
- blood supply of 214
- changes in, caused by tubercle bacilli 249
- developmental diseases of 351
 - in achondroplasia, 351
 - in cretinism, 354
 - in multiple cartilaginous exostoses 357
 - in osteogenesis imperfecta 356
 - in otitis fibrosa cystica 360
- diseases of 213
 - osteomyelitis, 215
 - periostitis 215
- early changes in, in acute osteomyelitis 218
- general texture of, changes in in rickets 92
- grafts in treatment of non union fractures 211
- in congenital syphilis 126
- infection of factors localizing 217
 - route of, 216
- marrow changes in in atrophic tuberculosis 257
 - in hypertrophic tuberculosis 260
 - rickets 92
 - tuberculosis 250
 - tuberculous disease of histology of 249
- membrane changes in, in syphilis 337
- naked eye appearances of in rickets when first stages complete 92
- nasal, tuberculosis of 588
- ossified in membrane changes in in rickets 92
- syphilis of 336
 - and tuberculosis of differential diagnosis of 341
 - changes in metaphysis in 336
 - periosteum in, 337
 - clinical features of 340
 - diagnosis of 340
 - formation of gummata in 337
 - pathology of 336
 - summary of 338
 - sites of occurrence of 336
 - treatment of 341
- temporal of new born infant with opened mastoid antrum 577
 - section of 583
- terminology of 213
- thickening of as sign of tuberculosis 260
- transplantation of in paralytic deformity of ankle joint 963
- tuberculosis of 244
 - atrophic macroscopic appearances of 257

Bone and Bones

- tuberculosis of, microscopic appearances in 257
- blood vessel changes in, 253
- Breslau's local tuberculin treatment of, 272
- clinical features of 260
 - general 262
 - local, 260
- cold abscess formation in treatment of 276
- complete fixation in 266
- diagnosis of 262
- differential diagnosis of 263
- encysted, 249
 - macroscopic appearances of 254
 - microscopic appearances of 255
- endarteritis obliterans and 233
- etiology of 244
- hypertrophic macroscopic appearances of 258
 - microscopic appearances in 258
- incidence of 246
- infiltrating 249
 - macroscopic appearances of 253
 - microscopic appearances of 256
- influence of injury in 246
- lamellar changes in 251
- marrow changes in, cellular 250
 - fibrous 251
- pathology of 247
 - varieties of 254
- periosteal changes in 252
- predisposing changes in influencing localization of 244
- predisposing influences of 246
- primary infections in 245
- prognosis of 263
- routes of infection in 244
- saccharose treatment of 272
- secondary infections in 245
- sinuses in treatment of 278
- site of influences deciding 247
- transverse section of 253
- treatment of 264
 - climatic conditions in 265
 - conservative 266
 - materials and methods for 267
 - diet in 266
 - drugs in 266
 - general 265
 - home conditions in 265
 - hospital conditions in, 265
 - operative 272
 - conditions governing success in, 272
 - conditions influencing decision in 273
 - contra indications in 272
 - gouging and scraping method after treatment 274
 - indications for 272
 - resection method, after treatment 275

- Bence-Jones bodies in urine in diffuse myeloma, 350
- Bennett's fracture, 183
- Bereneck's tuberculin, 119
- Bi-manual examination, in abdominal examination, 10
- Bier's, congestive treatment in tuberculosis of ankle-joint, 434
of elbow-joint, 446
of wrist-joint, 449
in tuberculous cervical adenitis, 641
- Bifid clavicle, 987
lobules, 569
- Bile ducts, diseases of, 864
- Bilious attack, as symptom of appendicitis, 826
- Billon in treatment of syphilis, results of, 135
- Billroth splint for deformity in knee-joint tuberculosis, 425
- Birth injuries of skull, 467
depressed fractures of vault, clinical pathology of, 469
diagnosis of, 469
treatment of, 470
intra-cranial hæmorrhage in, 470
- Bladder, absence of, congenital, 910
congenital malformations of, 901
septa of, 910
dilatation of, congenital, 910
diseases of, 900
inflammatory, 921
examination of, in enuresis, 918
extroversion of, 901
clinical features, 904
pathology of, 902
etiology of, 901
extensive, 905
in female, 904
treatment, 905
operative, 906, 908
post-operative, 909
full, decubitus in, 5
hypertrophy of, congenital, 910
injury to, as complication of operation for inguinal hernia, 763
stone in, symptoms of, 924
streptothrix injections of, 923
tumours of, 925
- Blake extension method, for fracture of femur, 195
- Bleeder's joint and acute infective synovitis, differential diagnosis of, 367
- Blood, administration of, to recipient, in transfusion, 68
citratd, transfusion of, 65
collection of, from donor, for transfusion, 67
compatibility of, tests for, 59
microphotographs of, 60
diseases of, surgical aspects of, 459
- Blood, group tests, direct, advantages and disadvantages of, 62
indirect, advantages and disadvantages of, 61
technique of, 59
direct test, 61
indirect test, 59
groups and Mendelian law of inheritance, 58
groups in transfusion, 56
human, biological activator action of, in transfusion, 46
capability of coagulation and of initiating clotting of in transfusion, 45
in transfusions and infusions, 43
oxygen-carrying capacity of, 44
physical properties of, 43
serological properties of, 45
incompatibility of, in transfusion, clinical signs of, 62
dangers of, 56
infection of, avenues of, 216
tuberculous cervical adenitis, 629
normal, in infancy and childhood, 459
pressure reading chart in dissection of tuberculous cervical glands, 38
readings during major operations, importance of, 37
supply of bone, 214
of palate, 545
of vertebra, 282
transfusion of, 56, 68
dangers of, incompatibility, the blood groups, 56
in anæmia, 460
in Henoch's purpura, 461
in melæna neonatorum, 463
in symptomatic purpura, 460
withdrawal of, from donor, method of, 67
vessels, change in, in bone tuberculosis, 253
in hypertrophic tuberculosis, 258
in joint tuberculosis, 377
injury to in operative treatment of tuberculous cervical adenitis, 646
great, changes in, in Potts' disease, 285
examination of, in Potts' disease, 302
- Body attitude, in Potts' disease, 294
heat, conservation of, to prevent surgical shock, 39
importance of, insurgical shock, 10
relative proportion of, at different ages, 9
- Bone and Bones :
affected by acute osteomyelitis, table of, 218

- Cabot's posterior wire splint for fracture of femur 193
 wire splint for fracture of leg 203
 Calcium metabolism and non union of fractures, 212
 Calculus renal, 899
 treatment of 900
 and tuberculosis of kidney differential diagnosis of, 899
 vesical 924
 Calliper knock knee splint 1061
 Calmette's ophthalmic reaction 110
 Calot's method of treating kyphosis in Potts disease 317
 solutions for treatment of cold abscess 277
 tuberculous sinuses 280
 Calvé and Gauvain solution for treatment of cold abscess 278
 Cannula special for blood transfusion into superior longitudinal sinus 70
 Caput natiforma 466
 Carboloria caused by carbolic soak 17
 Cardiac embarrassment during transfusion 63
 Caries sicca, 438
 Carpus fractures of 182
 tuberculosis of 334
 incidence of 246
 Carrell treatment of severe wounds 15
 Cartilage articular changes in joint tuberculosis 375 376
 epiphyseal 213
 Catarrh, non suppurative of middle ear, 572
 Cauterization linear in treatment of prolapse of rectum 881
 Cellulitis and acute osteomyelitis differential diagnosis of 225
 as post operative complication of osteomyelitis 232
 Celluloid solution materials for making 1111
 splints for bone tuberculosis 268
 materials for making 1111 1112
 method of making 1109
 Cephalæmatoma, clinical pathology of 467
 diagnosis of 468
 treatment of 468
 Cephaloceles 473
 clinical history of 477
 contents of 476
 diagnosis of 478
 differential diagnosis of 478
 etiology of 473
 prognosis of 479
 sac of 476
 sites of 475
 structure of 475
 treatment of operative risk and results of 482
 special points in 480
 Cephaloceles treatment of, technique of 480
 post operative 482
 varieties of, 474
 Cerebral decompression in treatment of spastic paralysis 984
 edema in fracture of skull 513
 Cerebro spinal fluid course of 485
 method of absorption of, 485
 physiology of 483
 sources of 483
 Certus glue composition of 1111
 Cervical abscess in Potts disease, 286
 ribs, 692
 supernumerary 673
 vertebra third assimilation of with axis 691
 Cheek dermoid cysts of 540
 Chest and abdominal wall burns of, toxic appearance of, 22
 congenital malformations of 671
 deformities of acquired 673
 rachitic 674
 diseases of 671
 examination of methods of, 10
 flat treatment of 675
 funnel 674
 upper burns of 29
 wall changes in, in scurvy, 675
 Chevalier Jackson's direct laryngoscope 594
 Chiens line 186
 Child examination of mouth and fauces 10
 psychological considerations in 1
 general appearance of in acute osteomyelitis 223
 inspection of, 3 4
 the breath in 6
 the cry in 5
 decubitus in 4
 facial expression in 4
 posture in 4
 the skin in 51
 physical examination of 6
 abdomen in 9
 chest in 10
 gait or limp in 10
 general development in 8
 pulse in 7
 respiration in 7
 temperature in, 8
 psychology of 1
 questioning of attendants in date of onset of present illness 3
 family history of 3
 mode of attack and symptoms 4
 post natal history of 3
 previous treatment 4
 expression of disease in and features which modify it 2
 Childhood duration of, 2

- Bone and Bones:**
 tuberculosis of, treatment of, varieties of, 272
 preventive, 264
 special methods of, 271
 trypsin treatment of, 271
 tumours of, 342
 innocent, exostoses, 342
 chondromata, 344
 fibromata, 345
 myeloma, 345
 osteomata, 342
 cancellous type, 343
 ivory type, 342
 malignant, cortical sarcoma, 346
 diffuse myeloma, 350
 endosteal sarcoma, 346
 periosteal sarcoma, 346
 primary, 345
 sarcomata, 345
 varieties of, 347
 secondary, 349
 treatment of, 349
 primary, 342
 sites of, 342
 Boston long brace, treatment of genu varum by, 1066
 Bovine and human tuberculosis, comparison of, 104
 Bowleg (*see* Genu varum)
 Braces, long, for genu valgum, 1060
 metal, in treatment of Potts' disease, varieties of, 314
 varieties of, for treatment of genu varum, 1065, 1066
 rachitic knock-knee, 1058
 Brachial plexus, operative repair of, in obstetrical paralysis, 1010
 Brackett-Lovett method of applying plaster jacket, 314
 Bradford bed frame in treatment of Potts' disease, 307
 Bradford Goldthwaite's genuclast, 425, 426
 Brain, laceration of, in fracture of skull, 513
 lesions of, spastic gait in, 11
 œdema of, as indication for transfusion and infusion, 55
 tumours of, adenoma, 520
 epithelial, 520
 gliomata, 520
 pathology of, 519
 psammoma cholesteatoma, 520
 sarcomatous, 520
 surgical, 521
 symptoms of, focal, 521
 general, 520
 tuberculous, 519
 Branchial cysts, clinical features of, 612
 diagnosis and treatment of, 613
 method of formation of, 612
 fibro-chondromata, 613
 treatment of, 614
 Branchial fistulae, clinical features of, 610
 diagnosis and treatment of, 611
 Breath, in diagnosis, 6
 Breslau's local tuberculin treatment of bone tuberculosis, 272
 Bridge grafts, treatment of severe mid-dorsal scoliosis by, 738
 Bright's disease, decapsulation of kidney in, 893
 Brodie's abscess as complication of osteomyelitis, 240
 in upper metaphysis of tibia, 240
 Bronchitis, as complication of hare lip, 529
 Bronchoscopy for foreign bodies, 596
 Brophy's operation for cleft palate, 554
 Bryant's triangle, 186, 403
 Buhl's disease, 866
 Burghard operation for congenital dislocation of hip, 1045
 Burns and scalds, 19
 as indication for transfusion and infusion, 52
 associated diseases in, 21
 clinical pathology of, immediate shock, 20
 stage of reaction, 21
 recovery, 23
 toxæmia, 21
 comparison of, 19
 contraction following, prevention of, 31
 healing of, homogenous grafts in, 31
 skin-grafting in, 28
 Stent method, 30
 Thiersch method of, 29
 after-treatment, 30
 stage of, 28
 prognosis of, factors influencing, 23, 24
 secondary toxæmia in, 53
 septic, 27
 absorption in, 22
 treatment of by Carrol-Dakin method, 28
 stage of reaction following, treatment of, 25
 statistics of, 24
 toxæmia following, treatment of by Robertson's method, 25
 treatment of, general, 24
 immediate shock following, 24
 local, alcohol treatment, 26
 aluminium aniline preparations in, 26
 ambrian and paraffin applications in, 26
 picric acid treatment, 26
 primary excision, 26
 Bursitis, periarticular, and joint tuberculosis, differential diagnosis of, 388

- Cabot's posterior wire splint for fracture of femur 193
 wire splint for fracture of leg 203
 Calcium metabolism and non union of fractures 212
 Calculus renal 899
 treatment of 900
 and tuberculosis of kidney differential diagnosis of 890
 vesical 924
 Calliper knock knee splint 1061
 Calmette's ophthalmic reaction 110
 Calot's method of treating hyphosis, in Potts disease 317
 solutions for treatment of cold abscess 277
 tuberculous sinuses 280
 Calve and Gauvain solution for treatment of cold abscess 278
 Cannula special for blood transfusion into superior longitudinal sinus 70
 Caput natiforme 466
 Carboloria caused by carbolic soak, 17
 Cardiac embarrassment during transfusion, 63
 Caries sicca 438
 Carpus fractures of 182
 tuberculosis of 334
 incidence of 246
 Carrell treatment of severe wounds 15
 Cartilage articular changes in joint tuberculosis 375 376
 epiphyseal 213
 Catarrh, non suppurative of middle ear 572
 Cauterization linear in treatment of prolapse of rectum 881
 Cellulitis and acute osteomyelitis differential diagnosis of 225
 as post operative complication of osteomyelitis 232
 Celluloid solution materials for making 1111
 splints for bone tuberculosis 268
 materials for making 1111 1112
 method of making 1109
 Cephalhematoma clinical pathology of 467
 diagnosis of 468
 treatment of 468
 Cephaloceles 473
 clinical history of 477
 contents of 476
 diagnosis of 478
 differential diagnosis of 478
 etiology of 473
 prognosis of 479
 size of 476
 sites of 475
 structure of 475
 treatment of operative risk and results of 482
 special points in 480
 Cephalocelus treatment of technique of, 480
 post operative, 482
 varieties of, 474
 Cerebral decompression in treatment of spastic paralysis 984
 oedema in fracture of skull 513
 Cerebro spinal fluid course of 485
 method of absorption of 485
 physiology of 483
 sources of 483
 Certus glue composition of, 1111
 Cervical abscess in Potts disease 286
 ribs 692
 supernumerary, 673
 vertebra third assimilation of with axis, 691
 Check dermoid cysts of, 540
 Chest and abdominal wall burns of toxic appearance of 22
 congenital malformations of 671
 deformities of acquired, 673
 rachitic 674
 diseases of 671
 examination of methods of 10
 flat treatment of 675
 funnel 674
 upper, burns of 29
 wall changes in in scurvy 675
 Chevalier Jackson's direct laryngoscope 594
 Chiene's line 186
 Child examination of mouth and fauces 10
 psychological considerations in 1
 general appearance of in acute osteomyelitis 223
 inspection of, 3, 4
 the breath in 6
 the cry in 5
 decubitus in 4
 facial expression in 4
 posture in 4
 the skin in 51
 physical examination of 6
 abdomen in 9
 chest in 10
 gait or lump in 10
 general development in 8
 pulse in 7
 respiration in 7
 temperature in, 8
 psychology of 1
 questioning of attendants in date of onset of present illness 3
 family history of 3
 mode of attack and symptoms 4
 post-natal history of 3
 previous treatment 4
 expression of disease in and features which modify it 2
 Childhood duration of 2

- Bone and Bones:
 tuberculosis of, treatment of, varieties of, 272
 preventive, 264
 special methods of, 271
 trypsin treatment of, 271
 tumours of, 342
 innocent, exostoses, 342
 chondromata, 344
 fibromata, 345
 myeloma, 345
 osteomata, 342
 cancellous type, 343
 ivory type, 342
 malignant, cortical sarcoma, 346
 diffuse myeloma, 350
 endosteal sarcoma, 346
 periosteal sarcoma, 346
 primary, 345
 sarcomata, 345
 varieties of, 347
 secondary, 349
 treatment of, 349
 primary, 342
 sites of, 342
 Boston long brace, treatment of genu varum by, 1066
 Bovine and human tuberculosis, comparison of, 104
 Bowleg (*see* Genu varum)
 Braces, long, for genu valgum, 1060
 metal, in treatment of Potts' disease, varieties of, 314
 varieties of, for treatment of genu varum, 1065, 1066
 rachitic knock-knee, 1058
 Brachial plexus, operative repair of, in obstetrical paralysis, 1010
 Brackett-Lovett method of applying plaster jacket, 314
 Bradford bed frame in treatment of Potts' disease, 307
 Bradford Goldthwaite's genuclast, 425, 426
 Brain, laceration of, in fracture of skull, 513
 lesions of, spastic gait in, 11
 œdema of, as indication for transfusion and infusion, 55
 tumours of, adenoma, 520
 epithelial, 520
 gliomata, 520
 pathology of, 519
 psammoma cholesteatoma, 520
 sarcomatous, 520
 surgical, 521
 symptoms of, focal, 521
 general, 520
 tuberculous, 519
 Branchial cysts, clinical features of, 612
 diagnosis and treatment of, 613
 method of formation of, 612
 fibro-chondromata, 613
 treatment of, 614
 Branchial fistulæ, clinical features of, 610
 diagnosis and treatment of, 611
 Breath, in diagnosis, 6
 Breslau's local tuberculin treatment of bone tuberculosis, 272
 Bridge grafts, treatment of severe mid-dorsal scoliosis by, 738
 Bright's disease, decapsulation of kidney in, 893
 Brodie's abscess as complication of osteomyelitis, 240
 in upper metaphysis of tibia, 240
 Bronchitis, as complication of hare-lip, 529
 Bronchoscopy for foreign bodies, 596
 Brophy's operation for cleft palate, 554
 Bryant's triangle, 186, 403
 Buhl's disease, 866
 Burghard operation for congenital dislocation of hip, 1045
 Burns and scalds, 19
 as indication for transfusion and infusion, 52
 associated diseases in, 21
 clinical pathology of, immediate shock, 20
 stage of reaction, 21
 recovery, 23
 toxæmia, 21
 comparison of, 19
 contraction following, prevention of, 31
 healing of, homogenous grafts in, 31
 skin-grafting in, 28
 Stent method, 30
 Thiersch method of, 29
 after-treatment, 30
 stage of, 28
 prognosis of, factors influencing, 23, 24
 secondary toxæmia in, 53
 septic, 27
 absorption in, 22
 treatment of by Carrol-Dakin method, 28
 stage of reaction following, treatment of, 25
 statistics of, 24
 toxæmia following, treatment of by Robertson's method, 25
 treatment of, general, 24
 immediate shock following, 24
 local, alcohol treatment, 26
 aluminium aniline preparations in, 26
 ambrin and paraffin applications in, 26
 picric acid treatment, 26
 primary excision, 26
 Bursitis, periarticular, and joint tuberculosis, differential diagnosis of, 388

- Congenital atresia of small intestine
 in new born 859
 cervical lymphangioma, 617
 cleft sternum 672
 club hand 994
 foot 1087, 1097
 constriction and syndactylism 937
 of extremities 1003
 contraction deformity of lower ex-
 tremity, 1088
 fingers 1003
 toes, 1080
 cystic hygroma of neck, 616
 defects of the humerus 992
 radius 993
 ulna 993 994
 deficiency of pectoral muscles 671
 diaphragmatic hernia 782, 783
 dilatation and hypertrophy of
 bladder, 910
 dislocation of elbow 1000
 hip 1024 1045
 metacarpo phalangeal joints 1000
 thumb, 1002
 upper extremity 998
 wrist 1000
 diverticula or fistula 798
 double hallux varus, 1081
 inguinal hernia 746
 with congenital umbilical hernia,
 777
 elevation of scapula 988
 errors of anus 869
 gastro intestinal tract, 795
 facial cleft with accessory auricle 526
 fistulae of ear 568
 flat foot 1071
 flexion contraction of knee 1107
 genu recurvatum 1105 1107
 gout 657
 hernia 745
 into umbilical cord 776
 hydrocele 943
 hydrocephalus in spina bifida 489
 hydronephrosis 598
 hygroma of neck 618
 hypertrophy of the pylorus 814
 laryngeal stridor 598
 lymphangioma of neck 618 619
 malformations of anus 870
 arm 985
 auricle 569
 bladder 901
 clavicle 987
 external ear 568
 face 524
 hand 985
 larynx 594
 nose 525
 rectum 874
 trachea 594
 myxœdema 354
 narrowing of œsophagus 796
 paralysis 948
 Congenital pouches of œsophagus 796
 scoliosis, 719
 stenosis of midgut, 797
 subluxation of astragalus 1072 1073
 syphilis causing hydrocephalus 491
 of bones 336 338
 talipes equino varus 1089 1098
 varieties of 1101
 ulna club hand 992
 umbilical hernia 773
 vertical septa 910
 wryneck 620
 Conjunctivitis post-anæsthetic treat-
 ment of 81
 Contusions and wounds 12
 in fracture of skull, 513
 Convalescence stage of, in Potts
 disease, 316
 Convalescent period of infantile para-
 lysis, treatment in 555
 Coryza rhinitis as complication of hare
 lip 529
 Costo transverse excision for paralysis
 in Potts disease, 322
 vertebral joints changes in in
 scoliosis 724
 Counter irritation combined with com-
 plete fixation in bone tuber-
 culosis 271
 in treatment of joint tuberculosis,
 392
 Coxa valgæ 1010
 treatment of 1019
 by sub trochanteric osteotomy
 1019
 Coxa vara 1013
 and congenital dislocation of hip
 differential diagnosis of 1013
 hip joint tuberculosis differ-
 ential diagnosis of 408
 diagnosis of 1017
 double 1018
 epiphyseal types of 1014
 etiology of 1013
 pathology of 1014
 prognosis of 1017
 rheumatic after treatment of 1049
 clinical features of 1018 1054
 pathological anatomy of 1047
 treatment of 1049
 rocking gait in 11
 signs and symptoms of 1015
 treatment 1017
 operative 1017
 varieties of 1016
 Coxalgia (see Hip joint tuberculosis
 of)
 Crab pattern splint in osteomyelitis of
 lower extremity 237
 Cranio tabes 337 340
 Cranium (see Skull)
 Cretinism 354 662
 bone changes in 354
 thyroid treatment of 256

- Chloroform, administration of, face,
treatment with vaseline be-
fore, 79
advantages and disadvantages of, 73
in general sepsis, contra-indicated, 73
- Chloroma, 463
in surgical diagnosis, 460
- Chondrodystrophia foetalis, 351
- Chondromata, 344
- Circumcision, complications of, post-
operative, 930
dressing after, method of, 930
in treatment of phimosis, 923
- Citrate solution, composition of, 65
- Citrated blood transfusion in spon-
taneous hæmorrhage in new-
born, 463
- Clavicle, absence of, congenital, 937
bifid, 937
fractures of, 143
clinical features of, 143
complete, treatment of, 144
incomplete, treatment of, 144
obstetrical, 140
treatment of, 140
by Sayre's adhesive plaster,
140
method of application
of, 140
prognosis of, 147
simple, 145
without displacement, 144
treatment of, 143
by Sayre's adhesive plaster,
stages in, 141
malformation of, congenital, 933
sarcoma of, 343
- Cleft palate, 542
clinical history of, 543
pathology of, 546
combined with hare-lip, treatment
of, 550
treatment of, operative, age in, 549
Brophy's method, 554
early, 549
failure in, 559
Ferguson method, 551
Lagenbeck's method, 551
Lane's flap method, 556
late, 550
preliminaries to, 550
two-stage method, 558
post-operative, 559
pre-operative, 548
varieties of, 546, 547
- Lefts, facial, 540
- Limate, ideal, for treatment of tuber-
culosis, 113
- Club foot, congenital, 1087
clinical features, 1091
diagnosis of, 1092
etiology, 1087
frequency of, 1083
of babies, treatment of, 1094
- Club foot, pathological anatomy of,
1089
prognosis of, 1092
treatment of, 1093
by open operations, 1100
in infants and young children,
1097
varieties of, 1101
- hand, 995
with congenital absence of radius,
993
- Coagulin ciba in spontaneous hæmor-
rhage in new-born, 463
injection of, in operation wounds,
17
- Coal-gas, poisoning by, as indication
for transfusion and infusion,
53
- Cock-up splint for wrist-joint tuber-
culosis, 450
- Cœliotomy for tuberculous ascites, 311
- Coley's treatment of malignant bone
tumours, 349
- Colic, decubitus in, 5
- Collars, cervical, in tuberculous cervical
adenitis, 642
- Colles fracture, 179
splint for, 181
treatment of, 180
law in congenital syphilis, 122
- Colon, dilatation of, congenital, with
hypertrophy, 853
clinical history, 853
diagnosis, 856
etiological pathology, 855
morbid anatomy, 855
treatment, 856
operative, 856
- Compression paraplegia, in Potts'
disease, causes of, 285
- Concussion in fracture of skull, 513
treatment of, 516
- Condyle of elbow, external, fracture of,
158
internal, fractures of, 157
- Condyles, fractures of, 165
- Congenital absence of anus, 372
treatment, 373
auricle, 563
bladder, 910
clavicles, 933
extremities, 935
fibula, 1103, 1105
kidney, 886
patella, 1107
sternum, 671
thymus gland, 665
tibia, 1104
affections of skull, 473
amputation, 935
anomalies of cervical spine, 691
patella, 1106
ribs, 673
spine, 691

- Congenital atresia of small intestine
 in new born 819
 cervical lymphangioma 617
 cleft sternum 672
 club hand 994
 foot 1087 1097
 constriction and syndactylism 987
 of extremities 1003
 contraction deformity of lower ex-
 tremity 1088
 fingers 1002
 toes, 1080
 cystic hygroma of neck, 616
 defects of the humerus 992
 radius 993
 ulna 993 994
 deficiency of pectoral muscles 671
 diaphragmatic hernia 782 783
 dilatation and hypertrophy of
 bladder 910
 dislocation of elbow 1000
 hip 1024 1045
 metacarpophalangeal joints 1000
 thumb 1002
 upper extremity, 998
 wrist, 1000
 diverticula or fistula 798
 double hallux varus 1081
 inguinal hernia 740
 with congenital umbilical hernia,
 777
 elevation of scapula 988
 errors of snus 869
 gastro intestinal tract 705
 facial cleft, with accessory auricle 526
 fistulae of ear 568
 flat foot 1071
 flexion contraction of knee 1107
 genu recurvature, 1105, 1107
 goitre, 657
 hernia 745
 into umbilical cord 776
 hydrocele 943
 hydrocephalus in spina bifida 489
 hydronephrosis 898
 hygroma of neck, 618
 hypertrophy of the pylorus 814
 laryngeal stridor 598
 lymphangioma of neck, 618 619
 malformations of anus 870
 arm 985
 auricle 569
 bladder 901
 clavicle 987
 external ear 568
 face 524
 hand 985
 larynx 594
 nose 525
 rectum 874
 trachea 594
 myxœdema 354
 narrowing of œsophagus 796
 paralysis 948
 Congenital pouches of œsophagus 796
 scoliosis, 719
 stenosis of midgut, 797
 subluxation of astragalus 1072, 1073
 syphilis causing hydrocephalus 491
 of bones 336 338
 talipes equine varus 1089, 1098
 varieties of 1101
 ulna club hand 992
 umbilical hernia 773
 vesical septa 910
 wryneck, 620
 Conjunctivitis post-anæsthetic treat-
 ment of 81
 Contusions and wounds 12
 in fracture of skull, 513
 Convalescence stage of in Potts
 disease 316
 Convalescent period of infantile para-
 lysis treatment in 955
 Coryza rhinitis as complication of hare
 lip 529
 Costo transverse excision for paralysis
 in Potts disease 322
 vertebral joints changes in, in
 scoliosis 724
 Counter irritation combined with com-
 plete fixation in bone tuber-
 culosis 271
 in treatment of joint tuberculosis
 392
 Coxa valga 1010
 treatment of 1019
 by sub trochanteric osteotomy
 1019
 Coxa vara 1013
 and congenital dislocation of hip
 differential diagnosis of 1035
 hip joint tuberculosis differ-
 ential diagnosis of 408
 diagnosis of 1017
 double 1018
 epiphyseal types of 1014
 etiology of 1013
 pathology of 1014
 prognosis of 1017
 rachiatic after treatment of 1049
 clinical features of 1048 1054
 pathological anatomy of 1047
 treatment of 1049
 rocking gait in 11
 signs and symptoms of 1015
 treatment 1017
 operative 1017
 varieties of 1016
 Coxalgia (see Hip joint tuberculosis
 of)
 Crab pattern splint in osteomyelitis of
 lower extremity 237
 Craniotomies 337 340
 Cranium (see Skull)
 Crotinism 354 662
 bone changes in 354
 thyroid treatment of 206

- Cross splint, Harley's, in fracture of clavicle, 146
- Croup, false, 597
- Crying, in diagnosis, 5
- Cryptorchism, 784
- Cubitus valgus, 1001
- varus, 1001
- Cystitis, bacteriology of, 921
- chronic, and tuberculosis of kidney,, differential diagnosis of, 890
- treatment of, 922
- development of, in vesical calculi, 925
- devitalizing factors of, 921
- examination in, 922
- non-tuberculous, 921
- pathology of, 922
- routes of infection in, 921
- symptoms and treatment, 922
- tuberculous, 923
- pathology, symptoms and treatment, 923
- Cystotomy, preliminary, in treatment of hypospadias, 935
- Cysts, branchial, 612
- dermoid and branchial, differentiation of, 614
- of face, 540
- neck, 614
- hæmorrhagic, of thymus, 666
- thyroglossal, 654
- Dactylitis, syphilitic, 339
- tuberculous, 330
- diagnosis of, 332
- multiple, 331
- pathology of, 331
- prognosis of, 333
- symptoms of, 331
- treatment of, 333
- by local fixation, 333
- operative, 334
- Decubitus, indications from, in disease, 4
- Deformities, osseous, in rickets, prevention of, 98
- sequence of, 94
- treatment of, 99
- rachitic, multiple, 86
- Deformity in diagnosis of tuberculosis of elbow-joint, 443
- hip-joint, 399
- shoulder-joint, 438
- wrist-joint, 449
- in hip-joint tuberculosis, correction of, methods for, 411
- in knee-joint tuberculosis, 421
- correction of, by Billroth splint, 425
- extension, 424
- genuclast, 425
- manipulation, 425
- plaster bandage, 424
- supra-condylar osteotomy, 426
- De Garmo truss, 754
- Dehydration as indication for transfusion and infusion, 51
- Deltoid, infantile paralysis affecting, 964
- Dermoid cysts of spine, 695
- of mid-line of back, 694
- of thyroid gland, 662
- Development, activity of, influence upon disease of, 2
- errors of, rare, 1102
- general, and hare-lip, 529
- in physical examination, 8
- Developmental diseases of bones, 351
- Dextrose, solutions, in transfusion and infusion, 48
- intravenous infusion of, 72
- Diaphyseal aclasis, 357
- Diaphysitis, 213
- complete necrosis of, modified operation in, 231
- tuberculosis of, causes of, 247
- Diaphysitis, tuberculosis of, causes of, 247
- Diet in bone tuberculosis, 266
- in proliferative arthritis deformans, 458
- Dietetic errors in etiology of rickets, 86, 97
- Diphtheria, laryngeal, 597
- Diplegia, spastic, Little's disease, 975
- neglected, example of, 980
- Disease in children, expression of, and features which modify it, 2
- features of, 4
- transmission of, by blood transfusion, 62
- Dislocation, congenital of, joints of upper extremity, 998
- Diverticula, congenital, 798
- Domestication theory, in etiology of rickets, 87
- Donovan's solution in bone tuberculosis, 266
- Dorsal abscesses in Potts' disease, 287
- splint, for fracture of forearm, 175
- Dorso-lumbar region, myelo-meningocele of, 696
- Drainage in treatment of acute suppurative meningitis, 518
- Dreyer's vaccine in treatment of tuberculosis, 120
- Drugs in bone tuberculosis, 266
- Drugs in proliferative arthritis deformans, 458
- in treatment of surgical shock, 41
- Dunn's operation for talipes calcaneus, 967
- Duodenum, foreign bodies in, 822
- Dyschondroplasia, hereditary deformation, 357
- Dysphagia in goitre, 659
- Dyspnœa in goitre, 659
- Ear, abnormally projecting, 569

- Ear, affections of 568
in congenital syphilis 128
external congenital fistulae of, 568
malformations of, 568
eczema of 570
tumours of, 571
foreign bodies in 569
middle catarrh of non suppurative, 572
treatment of 574
diseases of 571
inflammation of factors influence 572
suppuration of 574
wax in 570
Ebner's method of recording spinal deformity 298
Ectopia cordis 572
of testis 789
Ectromely 986
Eczema of external ear 570
Edinburgh Children's Hospital depot antiseptic of 14
Elbow joint acute infective synovitis of 372
deformity of in paralysis 962
dislocation of congenital 1000
treatment, 1000
fractures of 156
classification of 165, 169
treatment of 165 169
examination of method of 156
external condyle of, clinical features of 158
head and neck of radius clinical features of 164
internal condyle of clinical features of 157
epicondyle of, clinical features of 157
olecranon process of ulna fracture in clinical features of 163
prognosis of 165
separation of lower epiphysis of humerus in, clinical features of 162
supracondylar clinical features of 160
T shaped fracture of lower end of humerus causing 161
treatment of 165 169
types of 157
injury of diagnosis of 164
landmarks of 156
tuberculosis of 442
diagnosis of 444
differential diagnosis of 444
pathological anatomy of, 442
physical signs of 443
treatment of by Biers congestive method 446
injection 446
conservative 444
- Elbow joint, tuberculosis of treatment of, operative Kocher's excision 447
methods of, 446
posterior excision, 446
post-operative 448
reduction of deformity in, 444
limbless operation for congenital club foot, 1100
- Empyema, 675
adhesive diagnosis of by estimation of intra pleural tension 681
bacteriology of 677
incidence in relation to 678
pathology in relation to 677
prognosis in relation to 677
clinical history of 679
conditions simulating 679
definition of, 676
diagnosis of 679
diffuse, 677
encysted 677
incidence of 678
origin of, 676
pathology of, 676
physical signs of 679
prognosis of 680
treatment of, 680
operative, 682
after treatment 687
closed method 686
introduction of drainage tubes in, 684
irrigation method 687
persistence of discharge following 688
primary closure without drainage method 686
simple repeated aspiration method 687
thoracotomy with open drainage method 686
trochar and cannula method 687
seton 687
tuberculous 689
with adhesions treatment of operative 683
after treatment 685
without adhesions treatment of, operative 685
- Encephaloceles 475
anterior 476
crown 480
occipital 476 481
oxygen ventriculogram of 479
Endarteritis in joint tuberculosis 377
obliterations and bone tuberculosis 253
Ladostentis syphilitic 339
Endotheloma of thyroid gland 661
Entero colitis acute and intussusception differential diagnosis of, 846
Excision of tonsils 591

- Enuresis, lesions causing, treatment of, 919
 nocturnal, 913
 seriousness of, 914
 synaptic type, 918
 special treatment of, 920
 treatment of, 919
 educational, 919
 by improving the higher control, 919
- Eosinophilia, conditions associated with, 460
- Epicondyle, internal, of elbow, fractures of, 157
- Epididymis, diseases of, 945
 tuberculosis of, 945
 treatment of, 946
- Epididymitis, acute, 945
- Epiphyseal cartilage, 213
 area, changes at, in rickets, 91
- Epiphysis, 213
 femur, tuberculosis of, 248
 lower, of femur, separation of, 197
 complications of, 198
 humerus, separation of, 162
 radius, separation of, 178
 os calcis, diseases of, 1084
 separation of, and fractures, 136
 operative treatment of, 207
 tibia, Osgood Schlatter's disease of, 1069
 tuberculosis of, causes of, 248
 upper, of femur, separation of, 186, 188
 humerus, separation of, 149
- Epiphysitis and hip-joint tuberculosis, differential diagnosis of, 407
 syphilitic, and elbow-joint tuberculosis, differential diagnosis of, 414
- Epispadias, 940
 balanic, 941
 etiology of, 940
 extroversion of, 903
 in female, 941, 942
 in male, 940
 penile, 941
 peno-pubic, 940
 treatment of, 941
- Equino cavus, deformity of, 978
- Erb-Duchenne paralysis, 1005
- Erb's paralysis, 1005, 1009
- Erlanger and Gasser's solution in treatment of surgical shock, 42
- Erysipelas and acute osteomyelitis, differential diagnosis of, 225
- Erythema following artificial-light treatment, 116
 nodosum and acute osteomyelitis, differential diagnosis of, 225
- Ether, advantages and disadvantages of, 77
 value of warming of, during anaesthesia, 80
- Ethyl chloride anaesthesia, advantages and disadvantages of, 79
- Examination, in acute osteomyelitis, 224
 anal fissure, 878
 cystitis, 922
 enuresis, 918
 hypertrophy of pylorus, 817
 intussusception, 844
 phimosis, 927
 status thymo-lymphaticus, 668
 tuberculous cervical adenitis, 636
 of children, 1, 3
 physical, 6
- Exanthemata in etiology of bone tuberculosis, 246
- Excision, anterior, in shoulder-joint tuberculosis, 440
 Kocher's, in tuberculosis of elbow-joint, 447
 of hip-joint, conditions calling for, 418
 technique of, 418
 posterior, in tuberculosis of elbow-joint, 446
 shoulder-joint, 441
 primary, in treatment of burns and scalds, 26
- Exomphalos, 774, 775
- Exostosis, multiple cartilaginous, diagnosis of, 359
 differential diagnosis of, 359
 etiological pathology of, 357
 prognosis of, 359
 treatment of, 359
- Extension, crossed in hip-joint tuberculosis, 410
 for deformity in knee-joint tuberculosis, 424
 in tuberculosis of ankle-joint, 433
 joints, methods of, 389, 390
 method, Blake's, for fracture of femur, 195
 Russell's, for fracture of femur, 194
- Extremities, absence of, congenital, 985
 constriction of, congenital, 1003
 lower, burns of, severe, 20
 congenital contraction deformity of, 1088
 deformity of, in achondroplasia, 353
 paralysis, 959
 rickets, 93, 1047
 fractures of, 198
 treatment of, conditions for, 201
 joint lesions of, painful joint gait in, 11
 malformation of, 1102, 1104
 osteomyelitis of, splints for, 236
 paralysis of, correction of deformity in, 958
 shortening of, in knee-joint tuberculosis, 122
 surgical diseases of, 1013

- Extremities** malformation of, congenital 1108
 syphilitic bone affections of, 338
 upper burns of severe 19 20
 deformities of in rickets, 93
 development of, 935
 dislocations of congenital 998
 extensive scarring deformity following burns, 23
 fractures of, multiple, 151
 malformations of congenital 985
 surgery of 935
 Volkmann Leser contracture of 1010
- Eyelids** lymphangioma of 542
- Eyes** affections of in congenital syphilis 128
 care of in artificial light treatment 116
 in congenital syphilis 126
- Face and eyes** burns of severe, 22
 hand extensive scarring of, following burns 28
 bones tuberculosis of 325
 dermoid cysts of 540
 diagnosis and treatment 541
 development of 524
 fusion in 525
 hæmangiomas of 541
 lymphangioma of 542
 malformation of congenital 524
 types of 527
 surgery of 524
- Facial cleft** congenital with accessory auricle 526
 types of 540
 expression in surgical diseases 4
- Fascia** transplantation of in paralytic deformity of ankle joint, 969
- Fauces** examination of 10
- Feeding** in surgical shock 40
- Feet**, deformities of 1069
- Femora** inclination of normal 1051
- Femur** acute osteomyelitis of 235
 anatomy of 186
 changes in in congenital dislocation of hip 1028
 epiphysis of upper separation of 186
 fracture of in new born baby, treatment of 143
 fractures of 185
 obstetrical 142
 treatment of 143
 in foetal position 143
 by Thomas splint 143
 sites of 188
 supra condylar 197
 treatment of special points in, 196
 head of manipulation of in congenital dislocation of hip 1038
 position of in congenital dislocation of hip 1029
- Femur**, head of, reduction of, in congenital dislocation of hip 1039
 stages of, 1040
 left congenital shortening of, 1103
 longitudinal section through 213
 lower end and epiphysis tuberculous of 248
 neck of angles of, 1013 1014
 anterior curvature of, 1050
 fractures of 185
 osteomyelitis of 222
 periosteal sarcoma of, 346
 section through in knock knee 1053
 shaft of congenital deformity of, 1104
 fractures of 189
 extension methods in, 194
 spiral 191
 transverse 196
 treatment of at different ages 191
 rachitic deformities of 1050
 clinical features and treatment 1050
 tuberculosis of incidence of 246
 upper end of, acute osteomyelitis of 221
 ossification of 1047
 tuberculosis of hypertrophic, 259
 third of fracture of frequency of operative treatment for 207
- Ferguson** operation for cleft palate 551
- Fever**, glandular and tuberculous cervical adenitis differential diagnosis of 638
- Fibro chondromata**, branchial, 613
- Fibromata** 345
- Fibula**, absence of, congenital, 1103 1105
 acute osteomyelitis of, 234
 fractures of 198
 incomplete 204
 spiral, 200
 transverse 191
 treatment of conditions for 201
 tuberculosis of incidence of 246
- Fingers** constriction bands on 987
 contractions of 1002
 deformities of 1002
 fractures of 184
 multiple chondromata of 344
 webbed 1002
- Funson** lamp in treatment of tuberculosis 115
- Fissure** of anus 877
- Fistula** branchial 610
 congenital 798
 faecal as post operative complication of appendicitis 838
 rare 876
 recto urethral 875, 876
 vaginal 875
 vesical 875
 thyroglossal 655

- Fistula, umbilical, 798
urachal, 910
- Fixation, absolute, in joint tuberculosis, 391
complete, in bone tuberculosis, combined with counter-irritation, 271
heliotherapy, 271
hyperæmic treatment, 270
X-rays, 271
duration of, 269
importance of, 266
modification of, 269
principles governing, 266
hip-joint tuberculosis, 412
wrist-joint tuberculosis, 449, 450
- Flat chest, treatment of, 675
- Foot, 1070
anterior, 1078
congenital, double, 1071
degrees of, 1074
diagnosis of, 1074
examination and physical signs of, 1073
metatarsal, 1078
pathology of, 1071, 1072
rigid, 1077
symptoms of, 1072
treatment of, 1074
by restoration of normal function, 1075
operative, 1076
- Fluids, administration of, in surgical shock, 40
transfused and infused, therapeutic actions of, 43
- Focal tests in diagnosis of joint tuberculosis, 387
- Foerster's operation of resection of posterior nerve roots, 983
- Fœtal rickets, 351
- Fœtus, dissection of, showing descent of testis, 741, 742
- Fomentations, hot, in tuberculous cervical adenitis, 641
- Fontanelle, anterior, in hydrocephalus, 9
in rickets, 9
normal ossification of, 9
value of in blood, transfusion of, 68
- Foot, active support by, 1070
arches of, 1069, 1070
contracted or hollow, 1079
treatment, 1080
deformities of, appearances of solo impressions in, 1077
drill, in restoration of normal function of flat foot, 1075
fractures of, 207
functions of, 1069
long bones of, tuberculosis of, 330
movements of, 1070
passive support by, 1070
wear, in flat foot, 1076
- Forceps, for laminotomy, 323
- Forearm, amputation of, intra-uterine, 986
bones of, incomplete fracture of, in acute rickets, 91
fractures of, 171
classification of, 172
Colles, 179
greenstick, 174
ordinary, 172
Smith's, 182
splints for, 175
transverse, 173
in achondroplasia, 354
- Foregut, 791
development of, errors in, 795
segments of, changes in, 792
- Forehead, dermoid cysts of, 541
- Foreign bodies in duodenum, 822
in ear, 569
in larynx, 595
in stomach, 822
in trachea, 595
- Foreskin, contraction of, complicating circumcision, 931
- Fowler's solution in bone tuberculosis, 266
- Fracture, ante-natal, 137
and osteogenesis imperfecta, 137
treatment of, 139
Bennett's, 183
Colles, 179
greenstick of forearm, 171, 174
intra-uterine (*see* Fractures, ante-natal)
metacarpal, 183
non-union of, treatment of, operative, 211
obstetrical, 139
bones affected in, 140
etiology of, 139
of clavicle, 140
of femur, 142
of humerus, 142
of clavicle, 143
of humerus, 147
of ribs, 675
phalangeal, 184
Smith's, of forearm, 182
treatment of, operative, 207
- Fractures and separations of epiphysis, 136
classification of, 136
- Franum, ulcers of, 563
- Fragilitas osseum, 357
- Frame, for scoliosis correction, 733
Jones's single abduction, in osteomyelitis of lower extremity, 236
- Froelich's syndrome, 520
- Funnel chest, 674
- Furunculosis of meatus, 571
- Gait, fixed deformed, in physical diagnosis, 11

- Gait flaccid in physical examination, 10
 in physical examination 10
 in Potts disease 294
 painful joint in physical examination 11
 paralytic, in physical examination 10
 rocking in physical diagnosis 11
 spastic in physical examination 11
 Galyi in treatment of syphilis results of, 135
 Gault's operation for persistent deformity in hip joint tuberculosis 417
 Gas and oxygen anaesthesia value of 78
 Gastro intestinal tract congenital errors of 795
 congenital volvulus of, 800
 development of 791
 errors of rotation in 800 801
 Genital organs diseases of 926
 examination of in enuretics 918
 Genito urinary system surgery of 834 926
 Genu recurvature congenital, 1105 1107
 varum (bowleg) 1063
 and bow legs associated, 1095
 anterior 1067
 clinical features of, 1064
 etiology 1063
 pathology of 1064
 rheumatic 1062 1063
 double 1064
 treatment of, 1064
 by splints and braces 1065
 expectant 1065
 operative 1066
 Genuclast for deformity in knee joint tuberculosis 425
 Gillies operation for cleft palate 508
 Glands cervical tuberculosis of, 628
 dissection of blood pressure chart in 38
 lymphatic of neck incidence of disease of 632
 lympho sarcoma of 638
 surgical anatomy of, 630
 tuberculosis of 628 630
 sub maxillary, tuberculous operative removal of 643
 tuberculous of anterior and posterior triangles operative removal of 644
 Glycogenic reaction value of 409
 Goitre acquired 609
 congenital 657
 diagnosis and treatment of, 609
 fulminating 609
 pathology of 617 608
 exophthalmic 660
 Goldthwaite method of applying plaster jacket 314
 Grattan osteoclast 1061
 Greenstick fracture and acute osteomyelitis, differential diagnosis of 225
 femur 187
 forearm 171, 174
 ulna, 172
 Growth, activity of influence upon disease of 2
 Gum saline solution in transfusions and infusions 46
 intravenous infusion of, 72
 Gummata and bone tuberculosis differential diagnosis of 263
 Gymnastics treatment of scoliosis by, 731, 732
 von Hacker splint in fracture of humerus 142, 155
 Haemangioma of chest wall 672
 Haemangiomata of face 541
 Haemarthrosis and acute infective synovitis differential diagnosis of 767
 Haematoma auris 571
 Haematuria postural, 912
 complication by after operation for inguinal hernia 764
 rarity of in vesical calculi 925
 Haemoglobinuria 913
 Haemophilia joint haemorrhage in, 454
 treatment of 455
 transfusion of human blood in value of 45
 Haemoplastin in spontaneous haemorrhage in new born 463
 injection of in operation wounds 17
 Haemorrhage as cause of surgical shock 97
 complication of circumcision, 930
 extra dural in skull fracture, 510
 following tonsillectomy 592
 in new born spontaneous citrated blood transfusion in 463
 symptomatic, treatment of 462
 traumatic treatment of 462
 types of, 462
 indication for transfusion and infusion 49
 into and tuberculosis of knee joint differential diagnosis of 423
 intra cranial birth causing hydrocephalus 490
 etiology of 470
 non surgical treatment of 472
 surgical treatment of 471
 results of 472
 technique of 472
 secondary as post operative complication of osteomyelitis 232
 simulating surgical shock 40
 sub dural in skull fractures 510
 Haemorrhagic diseases as indication for transfusion and infusion, 52

- Hæmorrhagic diseases, transfusion of human blood in, value of, 45
- Halitosis in diagnosis, 6
- Hallux valgus, 1081
- varus, 1080
- Hamilton splint for abduction of leg at hip-joint, 1049
- synovitis of hip-joint, 371
- Hammock frame method of applying plaster jacket, 314
- Hamstrings, manipulation of, in treatment of congenital dislocation of hip, 1036
- Hand, burns of, severe, 19
- extensive scarring deformity of, following burns, 23
- left, polydactylism in, 1003
- long bones of, tuberculosis of, 330
- malformation of, congenital, 985
- multiple chondromata of, 344
- ulnar club, congenital, 992
- Hanot's cirrhosis, 866
- Hare-lip, classification of, 527
- clinical history of, 530
- pathology of, 528
- combined with cleft palate, treatment of, 550
- double, complete with projecting pre-labium, 530
- pre-maxilla, 529, 532
- etiology of, 527
- operative treatment of, 531
- complete lateral cleft, technique of, 534
- contra-indications in, 531
- double complete cleft with projecting pre-maxilla, technique of, 536
- incomplete cleft, technique of, 533
- modified Nelaton incision in, 534
- Rose incision in, 534, 536
- nasal and labial flap method, 534, 538
- Stevens's method, 535
- Terrace method, 539
- variations in, 539
- post-operative treatment of, 539
- pre-operative treatment of, 532
- prognosis of, 530
- varieties of, 526
- Harley's cross splint, in fracture of clavicle, 146
- Harrington's solution, composition of, 17
- Hawley's splint, for fracture of femur, 196
- wire extension splint, for fracture of phalanges, 185
- Head, cross-shaped, 466
- flat, 466
- injury of, conditions following, 514
- examination in, 514, 515
- Head, injury of, treatment of concussion effects in, 516
- position of, for ventriculography, 499
- saddle, 466
- supports in treatment of Potts' disease, types of, 315
- Heart, changes in, in Potts' disease, 285
- examination of, in Potts' disease, 302
- Heath's operation for mastoid, 584
- Hedrocele of rectum, 879
- Heliotherapy, artificial, in proliferative arthritis deformans, 458
- combined with complete fixation in bone tuberculosis, 271
- in surgical tuberculosis, 114, 115
- tuberculous cervical adenitis, 641
- Hemimely, 986
- Hemiplegia, spastic, 973
- Hemispondylia, 692
- Henle's spine, 578
- Henoch's purpura, 461
- and intussusception, differential diagnosis of, 846
- Heredity, influence of, on inguinal hernia, 744
- Hernia, 740
- anatomy of, 740
- congenital, 745
- diaphragmatic, congenital, 782
- treatment of, 783
- epigastric, pathology and treatment of, 781
- treatment of, operation for, 782
- femoral, 771
- diagnosis of, 771
- operation for, 772
- treatment of, 771
- inguinal, age incidence in, 743
- clinical features of, 748
- complications of, 764
- irreducibility, 764
- congenital double, 746
- diagnosis of, differential, 750
- direct, 770
- treatment of, 770
- etiology of, 740
- femoral, 768
- diagnosis of, 769
- pathology of, 768
- surgical anatomy of, 768
- treatment of, 769
- formation of the processus vaginalis and, 740
- forms of, 746, 747, 748
- heredity, influence of, 744
- left, vaginal in type, 749
- male, 740
- diagnosis of, 750
- mesentery abnormal and, 744
- pathology of, 744
- physical examination for, 718
- position of sac in the cord, 715
- radical cure of, 757, 758, 759, 760, 761
- right, funicular type, 747

- Hernia, inguinal, right vaginal type, 749
- sac contents of, 748
 - secondary etiological factors 743
 - sex incidence in 744
 - structures in the cord, 745
 - technique of post operative care 762
 - treatment of, 752
 - conservative 753
 - operative 755
 - contra indications 755
 - cost arrangements, 762
 - dressings 761
 - post-operative complications, 762
 - precautions 756
 - procedure of 750
 - time for, 755
 - irreducible treatment of 763
 - oblique type pathology of 743
 - sac wall tuberculosis of 767
 - strangulated 766
 - treatment of 766
 - umbilical 773
 - clinical features of, 776
 - congenital 773
 - factors in 777 778
 - pathology of 774 778
 - post natal, 777
 - radical cure of 780
 - after treatment 781
 - technique 780
 - treatment of 776 778
 - by mechanical occlusion of sac 778
 - by subcutaneous ligature of sac neck 779
 - indications and contra indications 779
 - results 777
 - varieties of, 773
- Heusner's glue composition of 269
- splint in bone tuberculosis 269
- Hibbs operation for Potts disease 318
- Hilton's white line 869
- Hindgut 792
 - development, errors of 802
 - segments of changes in 792
- Hip joint acute infective synovitis of 370
 - treatment of 371
- anatomical relations around 403
- congenital dislocation of rocking gait in 11
- disease simulating Potts disease 305
- dislocation of congenital 1024 1044
 - causation of 1027
 - clinical examination and physical signs of 1030
 - history of 1029
 - diagnosis of 1034
 - differential diagnosis 1034
 - etiology of 1025
- Hip joint dislocation of, palpation in 1031
 - pathology of 1027
 - prognosis of 1035
 - reduction of after treatment 1042
 - risks 1044
 - sex incidence in 1027
 - special features, 1032
 - treatment of, 1035
 - sex incidence in 1035
 - by manipulation 1035
 - by reduction 1035
 - technique 1036
 - operative 1045
 - indications 1045
 - types of operations 1045
 - X ray examination in 1033
 - in paralysis 960
 - post infective 1034
 - post paralytic 1034
- double congenital dislocation of, 1030
- early tuberculosis of painful joint gait in 11
- flexion and dislocation of in paralysis 959
- measurements at in congenital dislocation 1031
- movements at, in congenital dislocation 1031
- sub luxable, 1026
- tuberculosis of 295
 - absolute diagnosis of 406
 - anatomical peculiarities influencing 395
 - clinical signs and pathological conditions relationship of 405
 - complications of treatment of 416
 - differential diagnosis of 406
 - morbid anatomy of, 397
 - pathology of 395
 - physical examination of, 400
 - prognosis of, 409
 - duration of treatment and 409
 - results of 409
 - symptoms of 398
 - treatment of ambulatory stages of 415
 - by complete fixation duration of 414
 - in recumbency 412
 - conservative summary of 416
 - cross extension in 410
 - cure 412
 - during convalescent stage 415
 - general 410
 - conditions demanding modifications of 416
 - operative 417
 - after treatment 419
 - technique of 418
 - with deformity treatment of 410

- Hirschsprung's disease (*see* Colon dilatation of, congenital, with hypertrophy)
- Hodgen splint, for fracture of femur, 196
- Hodgkins' disease (*see* Lymphadenoma)
- Hoffa-Lorenz operation for congenital dislocation of hip, 1045
- Hoffa's operation, for obstetrical paralysis of upper arm, 1009
- Hoko's operation for congenital club foot, 1100
- Home and hygienic conditions in prophylaxis of rickets, 96
- Homogenous grafts in treatment of burns and scalds, 31
- Horse serum in spontaneous injection in new-born, 463
- Horse-shoe kidney, 885
- Humerus, acute osteomyelitis of, 237
 defects of, congenital, 992
 epiphysis of, lower, separation of, in fracture of elbow, 162
 with forward displacement of lower fragment, 163
 upper, anatomy of, 149
 separation of, 149
 after-treatment, prognosis and results, 153
 clinical features of, 152
 necessity of X-ray examination in, 152
 pathology of, 151
 treatment of, 152
- fracture of, ante-natal, in baby of four months, 138
 lower end, T-shaped, 161
 varieties of, 159
 with backward displacement, 159
 with separation of external condyle and epicondyle, 160
- obstetrical, 142
 treatment, 142
- shaft of, 153
 after-treatment of, 155
 clinical features of, 153
 prognosis in, 155
 treatment of, 153
 application of splint, 154
 von Haeker's splint, 155
 internal angular splint and traction, 155
 Jones's splint, 155
 modern views of, 156
 recumbent, with counter-traction, 155
 reduction of displacement, 153
 anæsthetic in, 153
 special considerations in, 155
- supra-condylar, 162, 164
 with lateral displacement of lower fragment, 161
 without displacement, 158
- Humerus, fracture of, surgical neck of, 150, 151
 with median displacement, 150
 transverse, of surgical neck, 149
 upper end of, examination of, 147
 greater tuberosity of, 148
 clinical features of, 149
 surgical neck, 147
 clinical features of, 148
 pathology of, 148
 situation of, 147
 types of, 147
 varieties of, 148
- tuberculosis of, incidence of, 246
- Hunter and Reyle's operation of sympathetic ramisection, 983
- Hydronephalocoeles, 475
- Hydrocele, 943
 congenital, 943
 diagnosis of, 944
 encysted, of cord, 943
 infantile, 943
 intermittent, 943
 of tunica vaginalis and inguinal hernia, differential diagnosis of, 751
 of cord, and inguinal hernia, differential diagnosis of, 750
 of neck, 616
 primary, 943
 secondary, 944
 treatment of, 944
 vaginal type of, 943
 varieties of, 943
- Hydrocephalus, 482
 anterior fontanelle in, 9
 classification of, 488
 clinical features of, 494
 congenital, 489
 development of, in spina bifida, 710
 diagnosis of, 500
 etiological pathology of, 489
 extraventricular, causes of, 492
 morbid anatomy of, 493
 suggested operation for, 508
 treatment of by carotid ligature, 507
 ventriculography in, 498
 factors influencing formation of, 488
 intra-ventricular, 483, 488
 ventriculography in, 497
- obstructive, 483
 physical examination in, 495
 and location of lesion, 497
 origin of, 495
 summary of, 500
 type of, 495
- sub-occipital operation for, 502
 surgical anatomy of, 483, 486
 treatment of, 500
- ventricular, causes of, 490
 treatment of, operative, 502
 closure of wound in, 507
 technique of, 502

- Hydrocephalus ventricular, with iter obstruction treatment of, operative, 505
- Hydronephrosis, acquired, 898
congenital, 898
- Hydrops complicating joint tuberculosis 392
- Hygroma, congenital cystic of neck, 616
- Hyperæmic treatment, combined with complete fixation in bone tuberculosis, 270
joint tuberculosis, 393
tuberculous sinuses, 281
- Hyperflexion bandage in fracture of elbow, 167
- Hypernephromata of kidney, 898
- Hypertonic salt, intravenous infusion of 72
- Hypertylemism 46.
- Hypophyseal duct tumours of, 520, 522
- Hypophysis, adenoma of 520
- Hypospadias 932
balanic type of 933
operation for 937
embryology of 933
etiology of, 933
penile type 933
anterior, operation for 937
perineal operation for 940
type of 933
posterior penile operation for, 940
treatment, 935
choice of cases, 936
essentials to success 936
varieties of types of 932
- Hypotension and surgical shock 32
- Illness acute and causation of rickets, 97
- Infancy, duration of 2
- Infants acute infective arthritis of 368
syphilitic synovitis of 451
- Infection, bacterial in etiology of rickets 87
in etiology of Perthe's disease 1021
of wryneck 622
- Infectious diseases infective arthritis as complication of 368
- Influenza in etiology of bone tuberculosis 246
- Infusion (*see also* Transfusions and infusions)
definition of 43
hypodermic atropin administration of 75
intermuscular method of 72
intrapertoneal method of 72
intravenous of dextrose solutions method of 72
of gum saline solution method of 72
of hypertonic salt method of 72
rectal method of 73
routes for 43
- Infusion subcutaneous, method of 72
treatment of tuberculosis of ankle joint 434
elbow joint, 446
joints 392
sinuses 279
wrist joint, 449
- Inspection in diagnosis of ankle joint tuberculosis 432
of hip joint tuberculosis 401
general in joint tuberculosis 382 383
local, in joint tuberculosis 382 383
- Intermuscular infusion method of 72
- Internal angular splint in fracture of humerus 15,
secretions deficiency of in etiology of rickets 87
- Intestinal loop rotation of stages, 793 794
wall tuberculosis of, 813
- Intestines diseases of, surgical 823
obstruction of, 807
acute 808
diagnosis of 801
habit of peritoneum to infection in 800
to strangulation in, 809
of unknown origin treatment of operative 862
prognosis 862
rapidity with which distention occurs in 859
symptoms of 800
treatment, 862
pre operative, 862
as post operative complication of appendicitis 838
definition and classification, 857
etiology 858
pathology of special considerations 859
- Intestine small, congenital atresia of in new born, 859
obstruction of acute 860
structure of and intussusception 841
tuberculosis of 813
pathology of 813
treatment 814
types of, 813
volvulus of 850
- Intracranial changes in skull fracture 510
pressure increase of in skull fracture 515
treatment of 517
- Intrapertoneal infusion method of 72
- Intra uterine disease in etiology of wryneck 622
- Intraventricular injection and lumbar puncture in diagnosis of hydrocephalus 496
of indicator in diagnosis of hydrocephalus 496
technique of 496

- Intubation, after-treatment in, 601
 instruments for, 599
 removal of tube in, 601
 technique of, 600
- Intussusception, 839
 appendicular, 842
 ascending or retrograde, 842
 changes in, pathological, 843
 diagnosis of, 846
 differential, 846
 entero-colic, acute, 840
 etiology of, 839
 examination in, 844
 ileo-cæcal, 842
 pathology of, 841
 prognosis of, 847
 sequelæ of, 843
 spontaneous cure of, 847
 symptoms and signs of, 844, 845
 treatment of, 847
 by injection of air or water, 847
 operative, 848
 by resection and anastomosis, 849
 and enterostomy, 849
 by temporary enterostomy and
 retention of the intussuscep-
 tion, 849
 when reduction is difficult or
 impossible, 849
 types of, 844
- Iodides in treatment of syphilis, 131
- Irrigation, intermittent, in treatment
 of severe wounds, 14
 technique of, 15
- Ischæmic theory of wryneck, 622
- Ischio-rectal abscess, 883
- Iter obstruction in ventricular hydro-
 cephalus, treatment of, opera-
 tive, 505
- Jaundice, aspects of, surgical, 864
 cirrhotic types of, 866
 etiology of, 864
 pathology of, 865
 treatment of, surgical, 865
 umbilical sepsis causing, 865
 varieties of, 866
- Jaw, alveolar margin of, cleft of, in
 hare-lip, 529
 lower, tuberculosis of, 326
 clinical features of, 327
 diagnosis of, 328
 incidence of, 246
 treatment of, operative, 329
 after-treatment, 329
- Joints, affections of, hysterical and
 tuberculous, differential diag-
 nosis of, 388
 in congenital syphilis, 127
 traumatic, 363
 treatment of, 364
 alteration in position of, as sign of
 tuberculosis, 381
 in use of, as sign of tuberculosis, 380
- Joints, blood supply of, 362
 diseases of, 362
 acute infective synovitis, 365
 arthritis, 365
 classification of, 363
 nomenclature of, 362
 distal interphalangeal, dislocations
 of, 186
 effusions, and syphilitic metaphysitis,
 339
 flail, operations to increase stability
 of, 965
 hæmorrhage in, in hæmophilia, 454
 treatment of, 455
 hysterical affection of, and hip-joint
 tuberculosis, differential diag-
 nosis of, 409
 stiffness in, as symptom of tuber-
 culosis, 380
 surgical anatomy of, classification
 of, 362
 syphilitic disease of, 451
 tuberculosis of, 374
 age and sex incidence in, 374
 avenues of entrance in, 374
 changes in component parts of, 375
 ligaments and soft parts in, 377
 related bones in, 376
 of blood vessels in, 377
 clinical evidences of, 379
 history of, 380
 deformity in, treatment of by
 extension, 390
 forcible replacement, 390
 operative, 391
 diagnosis of, actual, 385
 differential diagnosis of, 387
 examination in, method of, 382
 formation of primary tubercle in,
 375
 gross pathological varieties of, 377
 hydrops complicating treatment
 of, 392
 incidence of, in different joints, 374
 injury as predisposing factor in,
 374
 natural cure in, process of, 379
 pathology of, general, 374
 physical evidences of, 383
 prognosis of, conditions affecting,
 388
 symptoms of, summary of, 381
 treatment of, by counter-irritation,
 392
 by injections, 392
 solutions for, 392
 complications during conserva-
 tive treatment, 392
 conservative, 391
 stage of absolute fixation, 391
 general principles of, 389
 hyperæmic, 393
 operative, 393
 preliminary, 389

- Joints, tuberculosis of, treatment of
 preliminary, correction of
 deformity in 390
 extension for relief of pain 389
- Jones's abduction frame in synovitis of
 hip joint 371
 operation for adduction deformity in
 hip joint tuberculosis 417
 talipes calcaneus 968
 single abduction frame in osteo-
 myelitis of lower extremity,
 236
 splint, in fracture of humerus, 155
- Keratitis interstitial and syphilitic
 synovitis association of 453
- Kidney abnormalities of 885
 persistence of foetal lobulation 885
 absence of congenital 886
 adeno myo sarcoma (embryomata)
 of 894
 clinical features 896
 diagnosis 897
 pathology 894
 treatment 897
- decapsulation of in Bright's disease,
 893
 development of 884
 diseases of 884
 fused unilateral 886
 horse shoe 886
 inflammation of decubitus in 5
 infections of tuberculous 887
 pelvic 886
 polycystic 899
 position of changes in, 884
 stones in 899
 treatment of 900
 tuberculosis of 887
 as cause of hæmaturia 913
 clinical features of 886
 diagnosis of 889
 differential 889
 examination of 888
 pathology of 887
 prognosis 890
 treatment 890
 operative 890 891
 tumours of 893 895
 origin of 895
- Krimm's solution for treatment of
 cold abscess 277
- Klumpke type of obstetrical paralysis
 1006
- Knee joint acute infective synovitis of
 371
 treatment of 371
 deformities of in paralysis 960
 disease and hip joint tuberculosis
 differential diagnosis of 408
 flexion contraction of congenital
 1107
 tuberculosis of 420
 diagnosis of 422
- Knee joint tuberculosis of, differential
 diagnosis of 422
 pathological anatomy of 420
 physical signs of 420
 prognosis of 423
 suppuration in 424
 symptoms of, 420
 treatment of 424
 ambulatory stages of, 424
 convalescent 428
 curative 427
 plaster bandage for 420
 Thomas's knee splint for 426
 operative 428
 after treatment, 430
 technique, 429
 pain in, by counter irritation 424
 by extension 424
 with deformity, treatment of 424
- Knight brace treatment of genu varum
 by 1066
- Knock knee 1051
 changes in relation of femur and
 tibia in, 1053
 combination of with other de-
 formities 1056
 rachitic 1051 1054
 diagnosis of 1057
 double 1054 1055 1056
 method of measuring degree of,
 1056
 pathology of 1052
 prognosis of 1057
 symptoms of 1055
 treatment of 1057
 expectant 1057
 mechanical 1058
- spastic 1052
 treatment of by braces and splints
 duration of 1060
 by open operation (mesial) 1062
 by subcutaneous operation 1061
 operative 1060
 post operative 1062
 varieties of 1051
- Koch's old tuberculin 118
- Kocher's method of excising ankle
 joint 435
- Köhler's disease 350 1086
 etiology of 1082
 pathology of 1086
 treatment 1086
- Körner flap in radical mastoid opera-
 tion 583 584
- Kyphosis (see also Shoulder round)
 development of in Potts disease 283
 in Potts disease treatment of 316
 gradual correction 317
 risks and value of 318
 rapid correction 317
 risks and value of 318
 rachitic and syphilitic and Potts
 disease differential diagnosis
 of 304

- Intubation, after-treatment in, 601
 instruments for, 599
 removal of tube in, 601
 technique of, 600
- Intussusception, 839
 appendicular, 842
 ascending or retrograde, 842
 changes in, pathological, 843
 diagnosis of, 846
 differential, 846
 entero-colic, acute, 840
 etiology of, 839
 examination in, 844
 ileo-cæcal, 842
 pathology of, 841
 prognosis of, 847
 sequelæ of, 843
 spontaneous cure of, 847
 symptoms and signs of, 844, 845
 treatment of, 847
 by injection of air or water, 847
 operative, 848
 by resection and anastomosis, 849
 and enterostomy, 849
 by temporary enterostomy and
 retention of the intussuscep-
 tion, 849
 when reduction is difficult or
 impossible, 849
 types of, 844
- Iodides in treatment of syphilis, 131
- Irrigation, intermittent, in treatment
 of severe wounds, 14
 technique of, 15
- Ischæmic theory of wryneck, 622
- Ischio-rectal abscess, 883
- Iter obstruction in ventricular hydro-
 cephalus, treatment of, opera-
 tive, 505
- Jaundice, aspects of, surgical, 864
 cirrhotic types of, 866
 etiology of, 864
 pathology of, 865
 treatment of, surgical, 865
 umbilical sepsis causing, 865
 varieties of, 866
- Jaw, alveolar margin of, cleft of, in
 hare-lip, 529
 lower, tuberculosis of, 326
 clinical features of, 327
 diagnosis of, 328
 incidence of, 246
 treatment of, operative, 329
 after-treatment, 329
- Joints, affections of, hysterical and
 tuberculous, differential diag-
 nosis of, 388
 in congenital syphilis, 127
 traumatic, 363
 treatment of, 364
 alteration in position of, as sign of
 tuberculosis, 381
 in use of, as sign of tuberculosis, 380
- Joints, blood supply of, 362
 diseases of, 362
 acute infective synovitis, 365
 arthritis, 365
 classification of, 363
 nomenclature of, 362
 distal interphalangeal, dislocations
 of, 186
 effusions, and syphilitic metaphysitis,
 339
 flail, operations to increase stability
 of, 965
 hæmorrhage in, in hæmophilia, 454
 treatment of, 455
 hysterical affection of, and hip-joint
 tuberculosis, differential diag-
 nosis of, 409
 stiffness in, as symptom of tuber-
 culosis, 380
 surgical anatomy of, classification
 of, 362
 syphilitic disease of, 451
 tuberculosis of, 374
 age and sex incidence in, 374
 avenues of entrance in, 374
 changes in component parts of, 375
 ligaments and soft parts in, 377
 related bones in, 376
 of blood vessels in, 377
 clinical evidences of, 379
 history of, 380
 deformity in, treatment of by
 extension, 390
 forcible replacement, 390
 operative, 391
 diagnosis of, actual, 385
 differential diagnosis of, 387
 examination in, method of, 382
 formation of primary tubercle in,
 375
 gross pathological varieties of, 377
 hydrops complicating treatment
 of, 392
 incidence of, in different joints, 374
 injury as predisposing factor in,
 374
 natural cure in, process of, 379
 pathology of, general, 374
 physical evidences of, 383
 prognosis of, conditions affecting,
 388
 symptoms of, summary of, 381
 treatment of, by counter-irritation,
 392
 by injections, 392
 solutions for, 392
 complications during conserva-
 tive treatment, 392
 conservative, 391
 stage of absolute fixation, 391
 general principles of, 389
 hyperæmic, 393
 operative, 393
 preliminary, 389

- Mastoid antrum infections of** 576
 clinical features of 577
 pathology of 576
 treatment of 578
 bone tuberculosis of incidence of, 246
 incisions 580
 operations for, 578
 conservative 584
 radical 582
 modified 584
 simple 580
 after treatment 582
 types of 580
 surgical topography of 578
Mastoiditis acute 578
Mayo operation for penile hypospadias 938
Measurements in diagnosis of tuberculosis of hip joint 404
Meatus furunculosis of, 571
 ulcer of complicating circumcision 930
Meckel's diverticulum varieties of 798 799
Melena neonatorum blood transfusion in 403
Ménard solution for treatment of cold abscess 277
Mendelian law of inheritance and blood groups 58
Meningeal infections causing hydrocephalus 491
Meningitis acute suppurative, clinical features of 518
 surgical treatment of, 518
 epidemic cerebro spinal treatment of 519
 posterior basic treatment of 519
 types of 518
Meningo encephalocele 478
Meningoceles cranial 474
 occipital 474
 double 477
 spinal 698 699
Mercury in treatment of syphilis
 methods of administration of 130
Mesentery cyst of congenital 800
 long influence of on inguinal hernia 744
 tabes of 809
 treatment 810
Mesobranchial field of Hiss 651
Metabolism calcium in pathology of rickets 89
Metacarpal bones fractures of 183
 methods of splintage in 183
Metacarpophalangeal joints of hand
 congenital dislocation of 1000
Metacarpus fractures of 182
 tuberculosis of 330
 incidence of 246
Metal splints in bone tuberculosis 269
Metaphysis 213
 changes in in syphilis 336
 importance of 215
 tuberculosis of, incidence of 247
 upper, of tibia Brodie's abscess in 240
 tuberculosis of X ray appearance of 247
Metaphysitis syphilitic 339
Metastasis in periosteal sarcoma 346
 in secondary malignant tumours 350
Metatarsus tuberculosis of 330
 incidence of, 246
 varus (Froelich), 1081
Microbic count, importance of in secondary suture 16
Microcephalus treatment of 482
Microcephaly 465
Victorian disorders of 913
 in vesical calculi 924
 normal, 911
 reflex action of 916
Midgut 792
 development of, errors in 797
 segment of, changes in 792
Milk Designation Order 1923 and tuberculosis, 112
 supply, pure, in prophylaxis of tuberculosis 112
Mind disorders of in spastic paralysis, 973
Moro reaction 110
Morphia danger of administration of before anaesthesia 95
Moseley Moorhof's plug in operative treatment of bone tuberculosis 273
Mother, attention to health of in prophylaxis of rickets 96
Mouth and fauces examination of 10
 breathing adenoids as cause of 585
 surgery of 524
Movements in diagnosis of tuberculosis of hip joint, 402
 joints 404
 intentional individual in spastic paralysis 978
 limitation of in diagnosis of wrist joint tuberculosis 449
 restricted in diagnosis of ankle joint tuberculosis 432
 voluntary in diagnosis of joint tuberculosis 382 383
Mucosa
 rectal linear excision of in treatment of prolapse of rectum 881
Mucous membrane irritation of in protraction of intussusception 840
 surfaces in congenital syphilis 124
Murphy's glycerol gelatin formalin plug in operative treatment of bone tuberculosis 274
Murray
 modification of Thomas arm splint 178

- Lagenbeck's operation for cleft palate, 551
- Lamellæ, changes in, in atrophic tuberculosis, 257
in hypertrophic tuberculosis, 258
- Lamellar changes in bone tuberculosis, 251
- Laminæ, changes of, in scoliosis, 724
- Laminectomy for paralysis in Potts' disease, 322
acute suppurative meningitis, 519
- Laminotomy forceps, 323
for paralysis in Potts' disease, 323
- Lamp, Finsen, in treatment of tuberculosis, 115
mercury vapour, in treatment of tuberculosis, 116
open carbon arc, in treatment of tuberculosis, 115
- Lane's flap operation for cleft palate, 556
- Lange's gold precipitation test in syphilis, 129
- Laryngeal stridor, congenital, 598
- Laryngismus stridulus, 598
- Laryngitis, spasmodic, 597
- Laryngoscope, Chevalier Jackson's, 594
- Laryngoscopy, 594
- Laryngotomy for foreign bodies, 595
inter-crico-thyroid, 603
- Larynx, anatomical peculiarities of, 593
congenital malformations of, 594
diphtheria of, 597
diseases of, 597
foreign bodies in, 595
treatment of, 595
operations on, 599
papilloma of, 598
treatment of, 598
- Leucocytosis, pathological, 459
- Leukæmia, lymphatic, radium therapy of spleen in, 460
X-ray therapy of spleen in, 460
- Leukopœnia, conditions associated with, 459
- Lexer's arteries, 215
- Ligaments and soft parts, changes in, in joint tuberculosis, 377
changes in, in congenital dislocation of hip, 1028
scoliosis, 724
operations on, in treatment of congenital club foot, 1100
stretching of, and femur manipulation, in congenital dislocation of hip, 1037
- Light, artificial, in surgical tuberculosis, 115, 116
treatment of tuberculous cervical adenitis, 641
- Limp in diagnosis of hip-joint tuberculosis, 400
mechanical, 11
physical examination, 10
- Lingual thyroid, 653
- Lipoma, sub-periosteal, and bone tuberculosis, differential diagnosis of, 263
- Lips, lymphangioma of, 542
- Liston's long splint, modification of, in knee-joint tuberculosis, 431
- Little's disease, 975
- Liver, diseases of, 864
tumours of, 866
simulating tumour of kidney, 897
- Lop-ear, 569
- Lordosis, spinal, abnormal degree of, in Potts' disease, 296
- Lumbar abscess in Potts' disease, 289
puncture in diagnosis of hydrocephalus, 496
increased intracranial pressure, 515
syphilis of nervous system, 129
treatment of acute suppurative meningitis, 519
- Lungs, diseases of, decubitus in, 5
- Lymphadenitis, ileo-cæcal and appendicitis, differential diagnosis of, 832
- Lymphadenoma and tuberculous cervical adenitis, differential diagnosis of, 638
clinical features of, 649
differential diagnosis of, 651
etiology of, 647
pathology of, 649
treatment of, 651
- Lymphangioma, cervical, congenital, 617
of face, 542
of tongue, 568
- Lymphatic infection of tuberculous cervical adenitis, 629
vessels, sealing of, by deep mattress suture, 18
- Lymphocytosis, conditions associated with, 460
- Lymphosarcoma and tuberculous cervical adenitis, differential diagnosis of, 639
- McEwan's triangle, 578
- Macrocephaly, 465
- Macrocheilia, 542
- Macroglossia, 563
- Madelung's deformity, 1001
- Malar bone, tuberculosis of, incidence of, 246
- Malgrino's deformity, 1001
- Manipulation, careless, as cause of surgical shock, 39
in deformity of knee-joint tuberculosis, 424
treatment of osseous deformity in rickets, 100
- Marasmus as indication for transfusion and infusion, 54

- lastoid antrum infections of, 576
 - clinical features of 577
 - pathology of 576
 - treatment of 578
- bone tuberculosis of incidence of 246
- incisions 580
- operations for, 578
 - conservative 584
 - radical 582
 - modified 584
 - simple 580
 - after treatment 582
 - types of 580
- surgical topography of, 578
- Mastoiditis acute 578
- Mayo operation for penulo hypospadias, 938
- Measurements in diagnosis of tuberculosis of hip joint 404
- Meatus furunculosis of 571
 - ulcer of complicating circumcision 930
- Meckel's diverticulum varieties of 798 799
- Melane neonatorum blood transfusion in 463
- Menard solution for treatment of cold abscess 277
- Mendelian law of inheritance and blood groups 58
- Meningeal infections causing hydrocephalus 491
- Meningitis acute suppurative clinical features of 518
 - surgical treatment of 518
- epidemic cerebro spinal treatment of, 519
- posterior basic treatment of 519
- types of 518
- Meningo encephalocele 478
- Meningocele cranial 474
 - occipital, 474
 - double 477
 - spinal 698 699
- Mercury in treatment of syphilis methods of administration of 130
- Mesentery cyst of congenital 800
 - long influence of on inguinal hernia 744
 - tabes of 809
 - treatment 810
- Mesobranchial field of His 651
- Metabolism calcium in pathology of rickets 89
- Metacarpal bones fractures of 183
 - methods of splintage in 183
- Metacarpo phalangeal joints of hand congenital dislocation of 1000
- Metacarpus, fractures of 182
 - tuberculosis of 330
 - incidence of 246
- Metal splints in bone tuberculosis 269
- Metaphysis 213
 - changes in, in syphilis, 336
 - importance of 215
 - tuberculosis of incidence of 247
 - upper, of tibia, Brodie's abscess in, 240
 - tuberculosis of X ray appearance of 247
- Metaphysitis syphilitic 339
- Metastasis in periosteal sarcoma 346
 - in secondary malignant tumours 350
- Metatarsus, tuberculosis of 330
 - incidence of 246
 - varus (Kroelich) 1081
- Microbie count importance of in secondary suture 16
- Microcephalus treatment of, 482
- Microcephaly 465
- Microtition disorders of 913
 - in vesical calculi, 924
 - normal 911
 - reflex action of 916
- Midgut 792
 - development of, errors in 797
 - segment of, changes in 792
- Milk Designation Order 1923 and tuberculosis 112
 - supply pure in prophylaxis of tuberculosis 112
- Mind disorders of, in spastic paralysis 973
- Moro reaction, 119
- Morphua danger of administration of before anaesthesia 95
- Mosetig Moorhofs plug in operative treatment of bone tuberculosis 273
- Mother, attention to health of in prophylaxis of rickets 96
- Mouth and fauces examination of 10
 - breathing adenoids as cause of 585
 - surgery of 524
- Movements in diagnosis of tuberculosis of hip joint 402
 - joints 404
 - intentional individual in spastic paralysis 978
 - limitation of in diagnosis of wrist joint tuberculosis 449
 - restricted in diagnosis of ankle joint tuberculosis, 432
 - voluntary in diagnosis of joint tuberculosis, 382 383
- Mucosa, rectal linear excision of in treatment of prolapse of rectum 881
- Mucous membrane irritation of in production of intussusception 840
 - surfaces in congenital syphilis 124
- Murphy's glycerol gelatin formalin plug in operative treatment of bone tuberculosis, 274
- Murray modification of Thomas arm splint, 178

- Muscles, adductor, manipulation of, in treatment of congenital dislocation of hip, 1036
 stretching of, in treatment of congenital dislocation of hip, 1037
 changes in, in congenital dislocation of hip, 1029
 in scoliosis, 724
 hamstring, stretching of, in treatment of congenital dislocation of hip, 1037
 healthy, education of in spastic paralysis, 978
 ilio-psoas, manipulation of, in treatment of congenital dislocation of hip, 1036, 1038
 neurotization of, in infantile paralysis, 965
 nutrition of, in treatment of flat foot, 1076
 of palate, 544
 operation on, in spastic paralysis, 980
 pectoral, congenital deficiency of, 671
 recti, divarication of, 782
 spastic, weakening power of, by division or crushing of the motor fibres, 982
 spinal, 690
 infantile paralysis affecting, 962, 963
 sterno-mastoid, branchial cyst of, 613
 transplantation of, in infantile paralysis, 964
 spastic paralysis, 981
 Muscular rigidity in knee-joint tuberculosis, 421
 of spine, in Potts' disease, 299
 wasting in bone tuberculosis, 261
 Myelo-cystocele, spinal, 701
 Myelo-meningocele, dorsal, 710, 711
 large, of dorso-lumbar region, 696
 lumbo-sacral, large, 705, 706
 spinal, 699
 zones of, 701
 Myelocele, 701
 Myeloma, 345
 diffuse, 350
 Myelomatosis, 350
 Myotomy, in spastic paralysis, 980
 open, for wryneck, 625
 Myxœdema, 662
 congenital, 354

 Nævoid tumour of back, simulating spina bifida, 709
 Napier brace, treatment of genu varum by, 1065, 1066
 Narath's sign in congenital dislocation of hip, 1033
 Neck, burns of, 29
 congenital cystic hygroma of, 616
 hygroma of, 618
 lymphangioma of, 618, 619
 Neck, dermoid cysts of, lateral, 614
 diagnosis of, 615
 treatment of, 616
 developmental errors of, surgical significance, 609
 hydrocele of, 616
 lymphatic cysts of, 616
 diagnosis and treatment of, 619
 natural cure of, 618
 pathology of, 617
 symptoms of, 618
 glands of, tuberculosis of, 628
 mid-line of, anatomy of, 601
 development of, clinical significance of, 651
 developmental errors of, associated with thyroglossal duct, 653
 minor, 653
 surgery of, 609
 Nelaton's line, 186, 403
 modified incision in hare-lip, 534
 Neo-salvarsan in treatment of syphilis, results of, 135
 Nephritis as indication for transfusion and infusion, 51
 Nervo paralysis in etiology of wryneck, 622
 roots, posterior, resection of, in spastic paralysis, 983
 supply of palate, 544
 transplantation of, in infantile paralysis, 965
 Nervous system, affections of, in congenital syphilis, 125, 128
 operations on, in spastic paralysis, 982
 Neuber's iodoform starch in operative treatment of bone tuberculosis, 274
 Neuralgia, spinal, and Potts' disease, differential diagnosis of, 304
 New-born, hæmorrhage of, 462
 Night cries as symptom of joint tuberculosis, 381
 Potts' disease, 292
 Nitro-benzol, poisoning by, as indication for transfusion and infusion, 53
 Nose, affections of, 585
 congenital malformation of, 525
 deformities of, and hare-lip, 528
 dermoid cysts of, 540
 Nostril, accessory, 525
 Novarsenobenzol in treatment of syphilis, results of, 135

 Ober's operation for congenital club foot, 1100
 Obstetrical fractures, 139
 paralysis, 1004
 Occipital bone, ankylosis of, with atlas, 691
 Œdema, acute, of thymus, 660
 cerebral, in fracture of skull, 513

- Esophagus, narrowing of, congenital, 96
- obliteration of, partial 796
- pouches of, congenital 796
- Olecranon process, fracture of 166 169
 - of ulna, fracture of in injury of elbow 163
- Operation and surgical shock 36
 - major, blood pressure readings during importance of 37
 - wound, 17
 - closure of, 18
- Ophthalmic-reaction (Calmette) 110
- Ophthalmoscope in diagnosis of increased intracranial pressure 515
- Opiate, during recovery from anaesthesia composition of 81
- Orbit dermoid cysts of, 540
- Orchitis acute 945
 - syphilitic 946
- Organotherapy in rickets 97
- Osteocalcic epiphysis of disease of 1084
 - tuberculosis of 334
 - treatment of operative 335
- O good Schlatter's disease 1007
 - diagnosis and treatment 1063
- Osteous changes in rickets 90
 - general distribution of 92
- Ossification abnormal, in Perthes disease 1023
- O testis, sclerosing and bone tuberculosis differential diagnosis of, 263
- Osteo-chondritis syphilitic 339
- Osteo chondro sarcomata 347
- Osteo myxo sarcomata, 347
- Osteo sarcomata 347
- Osteoclasia treatment of knock knee by 1060
 - osseous deformity in rickets by, 100
- Osteoclast Thomas's use of 101
 - varieties of 101
- Osteogenesis imperfecta, 356
 - and fractures ante natal 137
 - in baby of two and a half months 137, 138
- Osteomata cancellous type of 343
 - every type of 342
- Osteomyelitis acute 215 233
 - age influence in 217
 - bones affected by 218
 - changes in periosteum in 219
 - clinical features of 222 223
 - definition of 215
 - diagnosis of 224
 - diaphysectomy in indications for 232
 - differential diagnosis of 225
 - etiology of 216
 - summary of 218
 - late complications of adherent scar 242
 - Brodie's abscess 240
- Osteomyelitis, acute, late complications of, recurrent abscess 240
 - sequestrum formation in 239
 - operation for, 239
 - treatment of 238
- necrosis in pathology of 219
- neglected modified operation for, 231
 - of leg splints for 236
 - organisms in 216
 - pathological features of non-ossous 222
 - pathology of 218, 220
 - progress of infection in 220
 - post operative complications of 232
 - prognosis of, 226
 - pus formation in pathology of 219
 - regional considerations of 234
 - route of infection in 216
 - sequela of 238
 - sex incidence in 218
 - symptoms of 222
 - treatment of 226 238
 - conservative 227
 - operative after treatment 230
 - cases for 227
 - modifications of 231
 - technique of 228
- albuminosa (Olier), 242
- albuminous 219
 - clinical features of 227
 - conservative treatment of 227
 - chronic staphylococcal and bone tuberculosis differential diagnosis of 263
- serosa 242
 - treatment of 243
- serous 219
 - clinical features of 227
 - conservative treatment of 227
- syphilitic 337
- typhoid 240
 - pathology of 241
 - treatment of 242
- Osteoporosis in bone tuberculosis 251
- Osteosclerosis in bone tuberculosis 252
- Osteotomy cuneiform 102
 - in coxa vara 1018
 - in treatment of knock knee 1062
 - for persistent deformity in hip joint tuberculosis 417
 - in osseous deformities of rickets 101
 - linear in coxa vara, 1018
 - in rickets 101
 - sub trochanteric in treatment of coxa valgus 1019
 - supra condylar for deformity in knee joint tuberculosis 426
- Ostitis fibrosa cystica 360
 - treatment of 361
 - types of 360
- Otitis media catarrhal 572

- Muscles, adductor, manipulation of, in treatment of congenital dislocation of hip, 1036
 stretching of, in treatment of congenital dislocation of hip, 1037
 changes in, in congenital dislocation of hip, 1029
 in scoliosis, 724
 hamstring, stretching of, in treatment of congenital dislocation of hip, 1037
 healthy, education of in spastic paralysis, 978
 ilio-psoas, manipulation of, in treatment of congenital dislocation of hip, 1036, 1038
 neurotization of, in infantile paralysis, 965
 nutrition of, in treatment of flat foot, 1076
 of palate, 544
 operation on, in spastic paralysis, 980
 pectoral, congenital deficiency of, 671
 recti, divarication of, 782
 spastic, weakening power of, by division or crushing of the motor fibres, 982
 spinal, 690
 infantile paralysis affecting, 962, 963
 sterno-mastoid, branchial cyst of, 613
 transplantation of, in infantile paralysis, 964
 spastic paralysis, 981
 Muscular rigidity in knee-joint tuberculosis, 421
 of spine, in Potts' disease, 299
 wasting in bone tuberculosis, 261
 Myelo-cystocele, spinal, 701
 Myelo-meningocele, dorsal, 710, 711
 large, of dorso-lumbar region, 696
 lumbo-sacral, large, 705, 706
 spinal, 699
 zones of, 701
 Myelocoele, 701
 Myeloma, 345
 diffuse, 350
 Myelomatosis, 350
 Myotomy, in spastic paralysis, 980
 open, for wryneck, 625
 Myxœdema, 662
 congenital, 354

 Nævoid tumour of back, simulating spina bifida, 709
 Napier brace, treatment of genu varum by, 1065, 1066
 Narath's sign in congenital dislocation of hip, 1033
 Neck, burns of, 29
 congenital cystic hygroma of, 616
 hygroma of, 618
 lymphangioma of, 618, 619
 Neck, dormoid cysts of, lateral, 614
 diagnosis of, 615
 treatment of, 616
 developmental errors of, surgical significance, 609
 hydrocele of, 616
 lymphatic cysts of, 616
 diagnosis and treatment of, 619
 natural cure of, 618
 pathology of, 617
 symptoms of, 618
 glands of, tuberculosis of, 628
 mid-line of, anatomy of, 601
 development of, clinical significance of, 651
 developmental errors of, associated with thyroglossal duct, 653
 minor, 653
 surgery of, 609
 Nelaton's line, 186, 403
 modified incision in hare-lip, 534
 Neo-salvarsan in treatment of syphilis, results of, 135
 Nephritis as indication for transfusion and infusion, 51
 Nerve paralysis in etiology of wryneck, 622
 roots, posterior, resection of, in spastic paralysis, 983
 supply of palate, 544
 transplantation of, in infantile paralysis, 965
 Nervous system, affections of, in congenital syphilis, 125, 128
 operations on, in spastic paralysis, 982
 Neuber's iodoform starch in operative treatment of bone tuberculosis, 274
 Neuralgia, spinal, and Potts' disease, differential diagnosis of, 304
 New-born, hæmorrhage of, 462
 Night cries as symptom of joint tuberculosis, 381
 Potts' disease, 292
 Nitro-benzol, poisoning by, as indication for transfusion and infusion, 53
 Nose, affections of, 585
 congenital malformation of, 525
 deformities of, and hare-lip, 528
 dermoid cysts of, 540
 Nostril, accessory, 525
 Novarsenobenzol in treatment of syphilis, results of, 135

 Ober's operation for congenital club foot, 1100
 Obstetrical fractures, 139
 paralysis, 1004
 Occipital bone, ankylosis of, with atlas, 691
 Œdema, acute, of thymus, 666
 cerebral, in fracture of skull, 513

- Gastrophagus, narrowing of congenital 796
 - obliteration of partial 796
 - pouches of, congenital 796
 - Olecranon process fracture of 166 169
 - of ulna, fracture of in injury of elbow 163
 - Operation and surgical shock 36
 - major blood pressure readings during importance of, 37
 - wound 17
 - closure of, 18
 - Ophthalmic reaction (Calmette) 116
 - Ophthalmoscope in diagnosis of increased intracranial pressure, 515
 - Opiate during recovery from anaesthesia composition of 81
 - Orbit dermoid cyst of, 540
 - Orchitis acute 945
 - syphilitic 946
 - Organotherapy in rickets, 97
 - Os calcis epiphysis of disease of 1084
 - tuberculosis of 334
 - treatment of operative 335
 - Osgood Schlatter's disease 1067
 - diagnosis and treatment 1068
 - Ossseous changes in rickets 96
 - general distribution of 92
 - Ossification abnormal in Perthes disease 1023
 - Osteitis sclerosing and bone tuberculosis differential diagnosis of 263
 - Osteo chondritis syphilitic 339
 - Osteo chondro sarcomata 347
 - Osteo myxo sarcomata 347
 - Osteo sarcomata 347
 - Osteoclasia treatment of knock knee by, 1060
 - osseous deformity in rickets by 100
 - Osteoclast Thomas's use of 101
 - varieties of 101
 - Osteogenesis imperfecta 356
 - and fractures ante natal 137
 - in baby of two and a half months 137 138
 - Osteomata cancellous type of 343
 - ivory type of, 342
 - Osteomyelitis acute 215 233
 - age influence in 217
 - bones affected by 218
 - changes in periosteum in 219
 - clinical features of 222, 223
 - definition of 215
 - diagnosis of 224
 - diaphysectomy in indications for 232
 - differential diagnosis of, 225
 - etiology of 216
 - summary of 218
 - late complications of adherent scar 242
 - Brodie's abscess 240
 - Osteomyelitis, acute late complications of recurrent abscess 240
 - sequestrum formation in 239
 - operation for 239
 - treatment of 238
 - necrosis in pathology of 219
 - neglected modified operation for, 231
 - of leg splints for 236
 - organisms in 216
 - pathological features of, non osseous 222
 - pathology of 218, 226
 - progress of infection in 226
 - post operative complications of 232
 - prognosis of 226
 - pus formation in pathology of 219
 - regional considerations of 234
 - route of infection in 216
 - sequele of 238
 - sex incidence in 218
 - symptoms of 222
 - treatment of, 226 238
 - conservative 227
 - operative after treatment 236
 - cases for, 227
 - modifications of 231
 - technique of, 228
- albuminosa (Olier) 242
- albuminous 219
 - clinical features of 227
 - conservative treatment of 227
- chronic staphylococcal and bone tuberculosis differential diagnosis of 263
- serosa 242
 - treatment of 243
- serous 219
 - clinical features of 227
 - conservative treatment of 227
- syphilitic 337
- typhoid 240
 - pathology of 241
 - treatment of 242
- Osteoporosis in bone tuberculosis 251
- Osteosclerosis in bone tuberculosis 252
- Osteotomy cuneiform 102
 - in coxa vara 1018
 - in treatment of knock knee 1062
 - for persistent deformity in hip joint tuberculosis 417
 - in osseous deformities of rickets 101
 - linear in coxa vara 1018
 - in rickets 101
 - sub trochanteric in treatment of coxa valga 1019
 - supra condylar for deformity in knee joint tuberculosis 426
- Ostitis fibrosa cystica 360
 - treatment of 361
 - types of 360
- Otitis media, catarrhal 572

- Otitis media, tuberculous, 575
treatment of, 576
- Ovaries, tumours of, simulating tumour
of kidney, 897
- Oxycephaly, 465
- Oxygen, administration of, during
operation, 77
- Pad, application of, in treatment of
umbilical hernia, 779
- Pain, as symptom of bone tuberculosis,
261
elbow-joint tuberculosis, 443
hip-joint tuberculosis, 399
joint tuberculosis, 381
knee-joint tuberculosis, 421
osteomyelitis, 223
shoulder-joint tuberculosis, 438
stone in the bladder, 924
wrist-joint tuberculosis, 449
local or referred as symptom of
Potts' disease, 292
referred, in Potts' disease, 261
- Palate, blood supply of, 545
deformity of, and hare-lip, 529
development of, 546
hard, 543
muscles of, 544
nerve supply of, 544
soft, 543
structure of, 544
surgical anatomy of, 542
- Palm, burn of, resulting in contraction
deformity of thumb, 27
- Palmar splint in Bennett's fracture, 184
in fracture of forearm, 175
phalanges, 185
- Palpation in diagnosis of ankle-joint
tuberculosis, 432
hip-joint tuberculosis, 402
joint tuberculosis, 382, 383
in examination of abdomen, 10
chest, 10
- Pancreas, abscess of, 867
treatment of, operative, 868
surgical aspects of, 866
- Pancreatitis, acute, 866
treatment of, operative, 867
- Papilloma of larynx, 598
- Paracentesis tympani for middle-ear
suppuration, 574
- Paralysis, as symptom of Potts'
disease, 293
cerebral, 948
co-existence of, in spina bifida, 709
congenital, 948
examination for, in Potts' disease, 301
facial from trauma at birth, 472
flaccid, 948
in Potts' disease, treatment of, con-
servative, 321
operative, 322
infantile, 948
affecting deltoid, 964
- Paralysis, infantile, affecting long
spinal muscles, 963
posterior spinal muscles, 962
and joint tuberculosis, differential
diagnosis of, 387
clinical features, 951
convalescence stage of, 953
definition and etiology of, 949
diagnosis of, 953
flaccid or paralytic gait in, 11
old-standing, of upper extremity,
961, 962
operations for, to improve func-
tion, 963
pathology, 949
prognosis of, 954
stages of, 952
treatment of, 954
acute or introductory period, 954
during period of convalescence,
955
operative, 963
types of, 951
- obstetrical, 1004
causes of, 1005
clinical features of, 1006
diagnosis of, 1007
Erb-Duchenne type, 1007
prognosis of, 1008
sensory changes in, 1007
treatment, conservative, 1008
operative, 1009
types of, 1006
varieties and pathology of, 1005
- post-anæsthetic, treatment of, 81
- spastic, 948, 969
clinical features, 971
diagnosis of, 974
mental symptoms in, 973
pathology of, 970
prevention of deformity from, 978
prognosis of, 975
sensory changes in, 974
signs of, 974
treatment of, 976
by double extension, 981
conservative, 977
general, 979
operative, 976, 979
trophic changes in, 974
surgical considerations of, 948
temporary, induction of, by nerve
crushing, 982
- Paraphimosis, 931
etiology and pathology of, 931
signs and treatment, 932
- Parasites, sacral, 694
- Parents, treatment of, in congenital
syphilis, 130
- Parham's bands in operative treatment
of fractures, technique of
application, 208
- Paste, B.I.P. for mastoid operations,
composition of, 581

- Patella** abnormalities of congenital 1107
displacement of congenital 1107
fracture of transverse 199
slipping 1108
- Patella ligamentum** congenital elongation of 1108
- Patho physiological basis** of incontinence of urine 914
- Pectus carinatum** 674
excavatum 674
- Pediatric surgeon** qualifications of 1
- Pellagra** as indication for transfusion and infusion, 55
- Pelvis** acute osteomyelitis of 236
changes in in congenital dislocation of hip 1027
Potts disease 286
scoliosis 726
- Penis** straightening of in treatment of hypospadias 936
- Percussion in abdominal examination** 10
appendicitis 828
chest examination 10
- Peri anal abscess** 883
- Peri articular disease** and hip joint tuberculosis differential diagnosis of 409
- Periadenitis** 634
- Periartentia in joint tuberculosis** 377
- Perinephritis** and hip joint tuberculosis differential diagnosis of 409
Potts disease differential diagnosis of 305
- Periosteal changes in bone tuberculosis** 252
nodes and bone tuberculosis differential diagnosis of 263
- Periosteum** changes in in acute osteomyelitis 219
atrophic tuberculosis 257
hypertrophic tuberculosis 260
syphilis 337
dense method of formation of 253
porous method of formation of 252
- Periostitis** definition of 215
syphilitic 339
and bone tuberculosis differential diagnosis of 263
- Peripheral nerve lesions** flaccid or paralytic gait in 11
paralysis of 948
- Peritheloma** of thyroid gland 661
- Pertoneum** diseases of 802
inflammation of decubitus in 5
- Pertontitis** acute tests for 833
pneumococcal 802
clinical features of 804
correlation of 805
diagnosis of 806
etiology of 803
fulminating 804
pathology of 806
- Pertontitis pneumococcal**, primary or idiopathic 803
prognosis of 807
secondary 804
treatment of 807
operative 807
varieties of 802
- streptococcal** 808
- tuberculous** 810
acute obstruction in 812
caseous type of treatment by incisions 811
forms of 810
simulating tumour of kidney 897
treatment of medical 812
surgical 811
- Pertyphtitis** and Potts disease differential diagnosis of 305
- Pertosis** disease 1020
and hip joint tuberculosis differential diagnosis of, 408
course of, 1021
diagnosis of 1024
infection in etiology of 1023
physical examination in 1022
pseudo coxalgia 1021
radiographic signs of 1022
rickets in etiology of 1022
statistics of 1020
syphilis in etiology of 1023
trauma in etiology of 1022
treatment of 1024
- Phalanges** fractures of, 182 184
tuberculosis of 330
incidence of 246
- Phenol sulphone phthalein** for intra ventricular injection 496
- Phimosis** 926
clinical features of 926
examination in, 927
treatment of 928
- Phocomely** 986
- Phosphaturia**, 912
- Physical examination**, 6
- Picric acid** treatment of burns and scalds 26
- Pigeon breast** 674
- Plagiocephaly**, 465, 466
- Plaster bandage** in ankle joint tuberculosis 433
deformity in knee joint tuberculosis 424
knee joint tuberculosis 426
of Paris in complete fixation in bone tuberculosis 267
splint in fracture of forearm 176
hip joint tuberculosis 412
jacket fillet type 314
in treatment of Potts disease 312
contra indications of 312
hammock frame method, 314
suspension method, 312
Minerva type 314
- Pleura** diseases of decubitus in 5

- Pleurisy, diaphragmatic, and appendicitis, differential diagnosis of, 833
- Pleuro-pneumonia, basal, and appendicitis, differential diagnosis of, 833
- Pluriglandular therapy in rickets, 98
- Pneumococcus in causation of acute infective synovitis, 365, 366
- Pneumonia, post-anæsthetic, treatment of, 81
- Poliomyelitis and acute osteomyelitis, differential diagnosis of, 226
- anterior, and hip-joint tuberculosis, differential diagnosis of, 407
- Polydactylism, 1003, 1099, 1101
- example of, in hand and foot, 1004
- Polymely, 1102
- Polypus of rectum, 877
- Poroplastic splint in bone tuberculosis, 269
- Post-anæsthetic complications, conjunctivitis, treatment of, 81
- paralysis, treatment of, 81
- pneumonia, treatment of, 81
- treatment of, 81
- vomiting, treatment of, 81
- Potts' disease, 282
- anatomical varieties of, 283
- boarding or flattening of spine in, 296
- changes in heart and great vessels in, 285
- pelvis in, 286
- spinal cord and membranes in, 285
- thorax in, 286
- vertebra in, 283
- vertebral column in, 284
- clinical features of, 291
- cold abscess formation in, 286, 320
- sites of, 321
- treatment of, 321
- decubitus in, 5
- diagnosis of, 303
- differential diagnosis of, 304
- dorsal, diseases simulating, 304
- etiology of, 282
- examination of heart and great vessels in, 302
- for cold abscess formation in, 301
- paralysis in, 301
- inspection of spine in, 295
- kyphosis in, 295
- treatment of, 316
- lumbar abscesses in, 289
- and hip-joint tuberculosis, differential diagnosis of, 408
- natural cure of, method of, 290
- paralysis in, treatment of, conservative, 321
- operative, 323
- costo-transverso excision, 322
- Potts' disease, paralysis in, treatment of, operative, laminectomy, 322
- laminotomy, 323
- pathology of, 282
- physical examination in, 293
- prognosis of, 305
- referred pain in, 261
- scoliosis in, 295
- spinal lordosis in, 296
- stage of convalescence in, apparatus for, 316
- duration of, 316
- symptoms of, 291
- in special regions, 302
- treatment of, 306
- ambulatory, 310
- apparatus for, 311
- head supports, 315
- metal braces, 314
- plaster jacket, 312
- duration of, 315
- modifications of, for different sites, 315
- conservative, 306
- principles guiding, 306
- stage of convalescence in, 316
- general, 306
- local, 306
- operative, 318
- after-treatment, 320
- Albee's method, 319
- cases suitable for, 320
- Hibbs' method, 318
- results of, 320
- recumbent, duration of, 310
- indications for, 307
- methods of, 307, 309
- modifications of regional, 309, 310
- X-ray examination in, 302
- Potts' fracture, 204
- Pre-auricular dermoid cysts, 540
- Pre-coccygeal tumours, cystic, 695
- Pre-sacral tumours, cystic, 695
- Prescott le Breton's solution for treatment of tuberculous sinuses, 280
- Pressure, intracranial, abnormal, as indication for transfusion and infusion, 55, 56
- Pritchard's views, in otiology of rickets, 88
- Prolapse of rectum, 878
- Pseudo-coxalgia, 1021
- Pulse, average rate at different ages, 7
- in physical examination, 7
- Purgatives before anæsthesia, danger of, 75
- Purpura, abdominal, Henoch's, blood transfusion in, 461
- fulminans, 461
- hæmorrhagica, 461
- Henoch's, and intussusception, differential diagnosis of, 846

- Purpura idiopathic varieties of, 461
 simplex 461
 surgical significance of 460
 symptomatic blood transfusion in, 460
 conditions associated with, 460
 Pyelitis, 89f
 and appendicitis differential diagnosis of 831
 and tuberculosis of kidney differential diagnosis of, 890
 diagnosis of 892
 pathology of, 891
 prognosis of 892
 treatment of 892
 Pyelonephritis, 891 893
 and tuberculosis of kidney differential diagnosis of 890
 Pylorus hypertrophy of congenital 814
 diagnosis of 817
 etiology, 814
 pathology of 815
 prognosis 818
 symptoms, 816
 treatment of, 818
 by forcible dilatation 819
 methods 822
 post operative 822
 surgical 818
 normal sections of 817
 stenosis of congenital, operations for 821
 Pyrgocephaly, 485
 Quinsy 588
 Rachischisis partial 701
 Radio ulnar synostosis congenital 995
 clinical history 996
 etiology 995
 secondary factors 996
 treatment 998
 types of 996
 Radium therapy of spleen in lymphatic leukemia 460
 tuberculous cervical adenitis 641
 Radius absence of congenital with club hand 993
 acute osteomyelitis of 237
 and ulna, combined fracture of 172
 defects of congenital 993
 fractures of head and neck 164
 neglected 170
 lower end sub periosteal fracture of 180
 shaft of fracture of 173
 tuberculosis of incidence of 246
 tuberculous focus in 254
 Ramisection sympathetic, in spastic paralysis 983
 Rammstedt operation for congenital hypertrophy of the pylorus 820
 Ranula diagnosis of 561
 etiology of 560
 of right sub maxillary region 561
 treatment of 562
 varieties of 560
 Rauchfuss sling in treatment of paralysis in Potts disease 322
 Reaction stage of following burns and scalds 2f
 treatment of, 225
 Recovery, stage of following burns and scalds 23
 Rectal examination in appendicitis 828
 infusion method of 73
 Rectum, absence of 874
 atresia of lower end of 874
 congenital errors of 869
 malformations of 874
 development of 869
 diseases of 869
 occlusion of, membranous 875
 polypus of treatment of, 877
 prolapse of, 878
 and intussusception differential diagnosis of 847
 diagnosis 880
 etiology, 878
 prognosis 880
 treatment 880
 conservative 88f
 injection, 881
 linear cauterization, 881
 operative 88f
 varieties 878
 Rectus muscles divarication of, 782
 Reduction of Colles fracture 150
 deformity in ankle joint tuberculosis, 433
 Referred pain as symptom of Potts disease 292
 Reflex irritation and hip joint tuberculosis differential diagnosis of 407
 Respiration in physical diagnosis 7
 Retro pharyngeal abscess 564
 acute 580
 treatment of 567
 clinical features of 565
 diagnosis of 566
 in Potts disease 287
 prognosis of 567
 surgical anatomy of 564
 treatment of 567
 tuberculous 565
 treatment of 567
 types and pathology of 565
 Rheumatism acute articular and acute osteomyelitis differential diagnosis of 226
 and hip joint tuberculosis differential diagnosis of 408
 and tuberculosis of knee joint differential diagnosis of 423
 Rheumatoid arthritis proliferative (see Still's disease)

- Rhythm, education of, in spastic paralysis, 979
- Ribs, cervical, 692
 supernumerary, 673
 treatment of, 673
 congenital anomalies of, 673
 fractures of, 675
 tuberculosis of, 329
 incidence of, 246
- Rickets, age of onset of, 83
 anterior fontanelle in, 9
 diagnosis of, 96
 etiology of, 86
 auto-intoxication from intestinal canal in, 87
 conditions influencing, clinical observations on, 89
 dietetic errors and deficiency of fats in, 86
 domestication theory in, 87
 internal secretions, deficiency of, in, 87
 mild bacterial infection in, 87
 Pritchard's views (influence of acidosis) in, 88
 vitamine theory in, 88
 foetal, 351
 frequency of occurrence of, 83
 in etiology of chest deformities, 673
 Perthe's disease, 1022
 pathology of, 89
 calcium metabolism, changes in, 89, 90
 changes in, 95
 osseous changes in, 90
 at epiphyseal cartilage area, 90
 bone marrow, 92
 bones which are ossified in membrane, 92
 cranium, 94
 deformities of, sequence of, 94
 general distribution of, 92
 lower extremity, 93
 naked-eye appearances when first stage is complete, 92
 spinal column, 94
 stage of deformity, 93
 of imperfect ossification, 90
 remodelling, Wolff's law in, 95
 sub-periosteal region, 92
 thorax, 94
 upper extremity, 93
 physical signs of, 84
 prognosis of, 96
 surgical aspects of, general considerations of, 83
 symptomatology of, early, 84
 treatment of, medical, 96
 curative, summary of, 97
 organotherapy in, 97
 prevention of osseous deformities, 98
- Rickets, treatment of, medical, prophylaxis, 96
 attention to health of mother, 96
 to home and hygienic conditions, 96
 prevention and treatment of acute illness, 97
 regulation of diet in, 97
 surgical, 96
 of osseous deformity, 99
 by gradual manipulation, 100
 osteoclasia, 100
 osteotomy, 101
 splints, 99
 indications for, 99
- Ridlon method of applying plaster jacket, 314
- Right-angled, antero-posterior splint, in fracture of elbow, 168
 forearm, 176
- Rigidity in diagnosis of shoulder-joint tuberculosis, 438
- Ringer's solution in treatment of surgical shock, 41
- Robertson's treatment of toxæmia following burns, 25
- Robinson's flask splint, for fracture of phalanges, 185
- Rose's modified incision in hare-lip, 534, 536
- Royle and Hunter's operation of sympathetic ramisection, 983
- Royston, barrel-stave splint, in fracture of clavicle, 145
- Russel extension method for fracture of femur, 194
- Russell-Duplay method in treatment of penile hypospadias, 938, 939
- Saccharose treatment of bone tuberculosis, 272
- Sacral stitch method in treatment of prolapse of rectum, 882
- Sacro-coccygeal appendages, 693
 tumours, 693
- Sacro-iliac disease, and Potts' disease, differential diagnosis of, 305
- Salvarsan and related preparations, 131
 in treatment of syphilis, results of, 134
 injection of, choice of position in, 132
 technique of, 132
 into scalp vein, 133
 open operation, 133
 percutaneous, 133
 methods of administration of, 132
- Sarcoma, central, and bone tuberculosis, differential diagnosis of, 263
 cortical, 316
 endosteal, 316
 of thyroid gland, 681

- Sarcoma, periosteal, 346
and bone tuberculosis differential diagnosis of 263
- Sarcomata, classification of 344
of kidney, 898
of testis 947
- Sayre's method of treating fractured clavicle modification of 140
- Scalds (*see* Burns and scalds)
- Scalp, laceration of at birth, 452
- Scaphoiditis, tarsal, 1083 1084
- Scapula, acute osteomyelitis of 237
elevation of, congenital, 948, 990
diagnosis of 991
etiology of 990
pathology of 989
prognosis and treatment of 991
varieties of, 988
- Scar, adherent as complication of osteomyelitis 242
- Scarring deformity of arm and hands following burns 23
- Schaffer's lateral traction splint for fracture of femur, 189
- Schede's aseptic blood clot in operative treatment of bone tuberculosis 274
- Schlange's disease 242
- Schwartz frame for correction of hip flexion deformity 959
- Scoliosis 716
articular process changes in 724
clinical features of 728
congenital, 719
correction frame 733
costo vertebral joint changes in 724
deviation of spine and rib changes in 722
diagnosis of 729
differential 729
etiology of 717
examination for by general inspection 726
demonstration of lateral curve in 727
estimation of flexibility of spine in 727
of vertebral rotation in 727
in Potts disease 295
laminae changes in 724
lateral view of illustrating rib hump 723
mid dorsal treatment of by implantation of bridge grafts 738
pathology of 722
pedicles and transverse processes changes in 723
pelvic changes in, 726
postural acquisition of 720
etiology of 718
treatment of 730
prognosis of 729
record of deformity of 728
- Scoliosis, secondary influences in, 720
simple and Potts disease differential diagnosis of 304
soft parts, changes in 724
spinous process, changes in 723
static example of, 721
of mid-dorsal spine 724
of upper dorsal region 725 726
structural etiology of, 721
treatment of, 731
terminology of 716
thorax changes in 725
treatment of 730
by application of corrective jacket 734 736
foreflex correction, 734
gymnastics, 731
operative, 737
varieties of 716
vertebral changes in 723
visceral changes in 726
X ray examination of 728
- Scrotum, hematoma as complication after operation for inguinal hernia, 763
- Scurvy and acute osteomyelitis differential diagnosis of 225
changes in chest wall in 675
- Senn's decalcified bone clips in operative treatment of bone tuberculosis 274
- Sepsis, after operation for inguinal hernia 763
tonsillectomy 592
general chloroform in contra indicated 78
simulating surgical shock 40
umbilical causing jaundice 865
- Septic absorption symptoms of in osteomyelitis 223
- Septicæmias as indication for transfusion and infusion 53
- Sequestrum formation in acute osteomyelitis, 239
hypertrophic tuberculosis 259
- Sera in treatment of tuberculosis 120
tuberculous cervical adenitis 642
- Serological tests in surgical tuberculosis 111
- Serum antitetanic in severe wounds value of 12
- Sever-Fairbank operation for obstetrical paralysis of upper arm 1009
- Sgambatti's test in diagnosis of acute peritonitis 833
- Shock as indication for transfusion and infusion, 50
immediate in burns and scalds 20
treatment of 25
in fracture of skull 510
prophylaxis of by transfusion and infusion 50
sequels of in fracture of skull 511

- Rhythm, education of, in spastic paralysis, 979
- Ribs, cervical, 692
- supernumerary, 673
- treatment of, 673
- congenital anomalies of, 673
- fractures of, 675
- tuberculosis of, 329
- incidence of, 246
- Rickets, age of onset of, 83
- anterior fontanello in, 9
- diagnosis of, 96
- etiology of, 86
- auto-intoxication from intestinal canal in, 87
- conditions influencing, clinical observations on, 89
- dietetic errors and deficiency of fats in, 86
- domestication theory in, 87
- internal secretions, deficiency of, in, 87
- mild bacterial infection in, 87
- Pritchard's views (influence of acidosis) in, 88
- vitamine theory in, 88
- fœtal, 351
- frequency of occurrence of, 83
- in etiology of chest deformities, 673
- Perthe's disease, 1022
- pathology of, 89
- calcium metabolism, changes in, 89, 90
- changes in, 95
- osseous changes in, 90
- at epiphyseal cartilage area, 90
- bone marrow, 92
- bones which are ossified in membrane, 92
- cranium, 94
- deformities of, sequenoe of, 94
- general distribution of, 92
- lower extremity, 93
- naked-eye appearances when first stage is complete, 92
- spinal column, 94
- stage of deformity, 93
- of imperfect ossification, 90
- remodelling, Wolff's law in, 95
- sub-periosteal region, 92
- thorax, 94
- upper extremity, 93
- physical signs of, 84
- prognosis of, 96
- surgical aspects of, general considerations of, 83
- symptomatology of, early, 84
- treatment of, medical, 96
- curative, summary of, 97
- organotherapy in, 97
- prevention of osseous deformities, 98
- Rickets, treatment of, medical, prophylaxis, 96
- attention to health of mother, 96
- to home and hygienic conditions, 96
- prevention and treatment of acute illness, 97
- regulation of diet in, 97
- surgical, 96
- of osseous deformity, 99
- by gradual manipulation, 100
- osteoclasia, 100
- osteotomy, 101
- splints, 99
- indications for, 99
- Ridlon method of applying plaster jacket, 314
- Right-angled, antero-posterior splint, in fracture of elbow, 168
- forearm, 176
- Rigidity in diagnosis of shoulder-joint tuberculosis, 438
- Ringer's solution in treatment of surgical shock, 41
- Robertson's treatment of toxæmia following burns, 25
- Robinson's flask splint, for fracture of phalanges, 185
- Rose's modified incision in hare-lip, 534, 536
- Royle and Hunter's operation of sympathetic ramisection, 983
- Royston, barrel-stave splint, in fracture of clavicle, 145
- Russel extension method for fracture of femur, 194
- Russell-Duplay method in treatment of penile hypospadias, 938, 939
- Saccharose treatment of bone tuberculosis, 272
- Sacral stitch method in treatment of prolapse of rectum, 882
- Sacro-coccygeal appendages, 693
- tumours, 693
- Sacro-iliac disease, and Potts' disease, differential diagnosis of, 305
- Salvarsan and related preparations, 131
- in treatment of syphilis, results of, 134
- injection of, choice of position in, 132
- technique of, 132
- into scalp vein, 133
- open operation, 133
- percutaneous, 133
- methods of administration of, 132
- Sarcoma, central, and bone tuberculosis, differential diagnosis of, 263
- cortical, 346
- endosteal, 346
- of thyroid gland, 661

- Skull, fractures of 508
 basal, 510
 cerebral oedema in 513
 compression in 512
 concussion in 513
 contusion in, 513
 diagnosis of 515
 differential diagnosis of 516
 etiology of 509
 increased intracranial pressure in, 515
 treatment of 517
 intracranial change in 510
 laceration of brain in 513
 pathology of 509
 imperfect ossification of 467
 juvenile peculiarities of 508
 osteoma of 342
 rachitic deformity of 84
 surgery of 467
 syphilitic affections of, 340
 tuberculosis of incidence of, 446
 vault of, fracture of 509
 treatment of 517
- Sleep and rest in treatment of surgical shock 40
- Slung and bandage in shoulder joint tuberculosis 439
 method in elbow joint tuberculosis 445
- Smith Peterson operation for congenital dislocation of hip 1046
- Smith's fracture of forearm 182
- Sodium chloride solutions of hypertonic in transfusion and infusion 47
 in transfusion and infusion 47
- Solutions for injection treatment of cold abscess 277
- Spahlinger treatment of tuberculosis 121
- Spermatic cord encysted hydrocele of and inguinal hernia differential diagnosis of 750
 lipoma of and inguinal hernia differential diagnosis of 751
 torsion of complication by after operation for inguinal hernia 763
- Spina bifida 695
 age and sex incidence of 697
 and congenital hydrocephalus 459
 anterior 703
 clinical features of 705
 diagnosis of 707
 differential diagnosis of 708
 etiology of 703
 lumbar myelocoele type of 702
 malformations associated with 707
 myelo meningocele type radio gram of 708
 occulta 702 703
 treatment of, 713
- Spina bifida pathological anatomy of 698
 pathology of 697
 signs of 705, 706
 terminology of 696
 treatment of, 708
 conservative 710
 operative 709
 age incidence in 709
 condition of tumour wall in 709
 technique 710 711
 type suitable for 709
 variations of in different types 712
 types of 704
 varieties of 697
 X ray examination in 707
- ventosa 330
- Spinal anaesthesia 79
 column (*see* Spino)
 cord, changes in in Potts disease 285
 embryology of 697
 neural tube of, formation 698
- Spine acute osteomyelitis of, 238
 anatomy of 690
 anomalies of congenital 691
 boarding of in Potts disease 296
 cervical congenital anomalies of 691
 movements of, examination of in Potts disease 200
 tuberculosis of head extension apparatus for 300
 changes in, in Potts disease 284
 curves of 690
 deformities of in rickets, 94
 methods of recording 298
 dermoid cysts of 695
 diseases of 690
 dorsal anomalies of 692
 movements of, examination of in Potts disease 300
 dorso lumbar tuberculosis of 291
 embryology of 697
 flattening of in Potts disease 296
 flexibility of in scoliosis 727
 inspection of in Potts disease 295
 intervertebral arrangements of 690
 lateral deviation of in Potts disease 295
 lordosis of abnormal degree of in Potts disease 296
 lumbar anomalies of 692
 movements of examination of in Potts disease 301
 membranes of changes in, in Potts disease 285
 mobility of testing of 300
 movements of 691
 examination of in Potts disease 299
 muscles of 690
 paralysis of 962
 rigidity of in Potts disease 299

- Shock, surgical, 32
 and operation, 36
 anæsthetics, choice of, to diminish risk of, 37
 conservation of body heat, importance of, 39
 hæmorrhage as cause of, 37
 manipulations, careless, as cause of, 39
 preparation of patient to diminish risk of, 36
 preventive treatment of, summary of, 39
 time an important factor in, 37
 appearance in, 34
 blood in, "vital red" method of estimation, 33
 clinical features of, 33
 diagnosis of, 35
 etiology of, 32
 factors which predispose to the development of, 33
 in children, important distinctive features in, 34
 origin of, 32
 prognosis of, 36
 treatment of, 36
 active, 39
 drugs in, 41
 estimate degree of shock present, 39
 exclude possibilities of simulating conditions, 40
 feeding in, 40
 fluids, administration of, 40
 maintain and increase body heat, 40
 sleep and rest in, 40
 transfusions and infusions in, 41, 42
- Shoes, for talipes, 1096
- Shoulder-joint, acute infective synovitis of, 372
 anatomy of, 437
 deformity of, in paralysis, 961
 dislocation of, congenital, 998
 tuberculosis of, 437
 diagnosis of, 439
 pathology of, 437
 prognosis of, 439
 treatment of, by abduction splint, 439
 by sling and bandage, 439
 conservative, 439
 operative, anterior excision, 440
 after-treatment, 441
 posterior excision, 441
 after-treatment, 442
 types of, 440
- Shoulders, round, 713
 and Potts' disease, differential diagnosis of, 304
 diagnosis, 715
 flexible type of, treatment, 715
- Shoulders, round, in Potts' disease, 283
 pathology of, 714
 physical signs of, 714
 resistant type of, treatment, 715
 rigid type of, treatment, 715
 treatment of, 715
 operative, 716
 varieties of, 713
- Silk, fixation by, in paralytic dropfoot, 968
- Silverfork deformity, 179
- Sinclair's footboard for fracture of ankle, 205
 glue, composition of, 268
 modification of, 269
 splint in bone tuberculosis, 268
 splint for fracture of forearm, 177
- Sinus, longitudinal, superior, value of in blood transfusion, 70
 superior, longitudinal, insertion of cannula into in blood transfusion, sectional diagrams of, 70, 71
 thyroglossal, 655
- Sinuses, tuberculous, treatment of, 278
 by injection, 279
 contra-indications for, 280
 hyperæmic, 281
 preventive, 279
 Wright's, 281
- Skin and appendages in congenital syphilis, 125
 and mucous surfaces in congenital syphilis, 127
 applications, local, in tuberculous cervical adenitis, 641
 grafting in healing of burns, 28
 methods of, 28
 Thiersch grafts, technique of, 29, 30
 in diagnosis, 5
 overlying, changes in, in knee-joint tuberculosis, 422
 pre-operative preparation of, 17
 sterilization of, in operation wounds, 17
 stretcher, self-retaining, for Thiersch graft cutting, 30
 tuberculosis of, secondary to cervical gland tuberculosis, 114
- Skull, acute osteomyelitis of, 238
 anomalies of, 465
 asymmetrical, 465, 466
 basis of, fractures of, 510
 treatment of, 517
 birth injuries of, 467
 cephalhæmatoma, 467
 depressed fracture of vault, 469
 intracranial hæmorrhage in, 470
 congenital affections of, 473
 deformities of, 465
 in rickets, 94
 endothelioma of, 522
 flat bones of, tuberculosis of, 324
 treatment of, 325

- Stenosis congenital of nuchal, 797
- Stent method of skin grafting, technique of 30
- Sternal foramen 672
- Sternum cleft congenital 672
- congenital absence of 671
- Stevens method of treating, hare lip 535
- Stiff neck and Potts disease differential diagnosis of 304
- Stiffness as symptom of tuberculosis of elbow joint 443
- of hip joint, 398
- post-traumatic and elbow joint tuberculosis differential diagnosis of 444
- Still's disease and tuberculosis of hip joint, differential diagnosis of 409
- joints differential diagnosis of 387
- knee joint differential diagnosis of 423
- Stimson's splint for fracture of ankle 205
- Stitches rubber protected value of in deep wounds 16
- Stoffel's operation in paralysis 982
- Stomach foreign bodies in 822
- hypertrophy of congenital, 814
- Strauss modification of Ramstedt's operation for congenital hypertrophy of pylorus 820
- Streptococcal peritonitis 808
- Streptococcus pyogenes in causation of acute infective synovitis 365
- 366
- Streptothrix infections of bladder 923
- Stroud, pecten of 869
- Subastragaloid disease 436
- Submaxillary region lymphangioma of 617
- Suboccipital operation for hydrocephalus 502
- Subperiosteal region, changes at in rickets 92
- Subcutaneous infusion method of 72
- Supraclavicular region, dermoid cyst of 615 616
- Supracondylar fracture of elbow 160
- Surgeon pediatric qualifications of 1
- surgery accident burns and scalds 19
- Suspension extension splint for fracture of femur 196
- method of applying plaster jacket 312
- or galloway splint for fracture of femur 193
- Suture anal in treatment of prolapse of rectum 882
- primary in severe wounds 13
- secondary of severe wounds 15
- Sutures materials for in secondary suture 16
- Sutures, deep, catgut tanned or chromized in operation wounds, to be avoided 17
- Swelling as symptom of tuberculosis of elbow joint 443
- knee joint, 421
- wrist joint 449
- Syndactylism and congenital constriction 987
- webbed fingers 1002
- Synovial membrane changes in in joint tuberculosis, 375
- Synovitis acute infective 365
- after treatment of, 370
- diagnosis of 367
- differential diagnosis of 367
- etiology of, 365
- pathology of 368
- predisposing factors in 365
- prognosis of 368
- routes of infection in, 365
- sequence of infection in 363
- treatment of 368, 369
- types of infection in variations of 368
- tuberculous and acute infective differential diagnosis of 367
- infective and joint tuberculosis differential diagnosis of 387
- subacute and tuberculosis of knee joint, differential diagnosis of 423
- sphulitic and interstitial keratitis association of, 453
- and tuberculosis of knee joint differential diagnosis of 423
- of infants clinical features of 451
- prognosis of 452
- treatment of, 452
- of youth diagnosis of 453
- pathology of 452
- treatment of 453
- traumatic and joint tuberculosis differential diagnosis of 387
- tuberculous acute military 378
- chronic 378
- fibrous 379
- fungating 378
- granulating 378
- Syphilis acquired, 123
- congenital 123
- causing hydrocephalus 491
- Colles law in 123
- diagnosis of 128
- clinical evidences in child in 128
- parental history in 128
- serological 129
- etiology of 123
- manifestations of 124
- child history of 124
- early 124
- intermediate 126
- late 126
- introductory features 127

- Spine, physiology of, 690
 posterior angulation of, in Potts' disease, 295
 sarcoma of, 349
 surface anatomy of, 691
 transverse segmentation of vertebral bodies of, 692
 tuberculosis of, 282, 290 (*see also under Potts' disease*)
 incidence of, 246
 sites of, clinical features of, 295
 tumours of, 693
 upper dorsal, tuberculosis of, 287
- Splanchnic nervous system, arrangement of, and intussusception, 841
- Spleen, radium therapy of, in lymphatic leukaemia, 460
 X-ray therapy of in lymphatic leukaemia, 460
- Splenectomy in splenic anæmia, 460, 868
- Splenic anæmia, splenectomy for, 868
- Splint, abduction, in shoulder-joint tuberculosis, 439
 anterior in metacarpal fracture, 183
 antero-posterior, for Colles fracture, 181
 application of, in fracture of shaft of humerus, 154
 Billroth, for deformity in knee-joint tuberculosis, 425
 Cabot posterior wire, for fracture of femur, 193
 wire for fracture of leg, 203
 calliper knock-knee, 1060
 celluloid, for bone tuberculosis, 268
 method of making, 1109
 cock-up, for wrist-joint tuberculosis, 450
 crab pattern in osteomyelitis of lower extremity, 236
 dorsal, for fracture of forearm, 175
 for osseous deformity in rickets, 99
 for treatment of genu varum, 1065
 for wrist-joint fixation, 450
 von Hacker's, in fracture of humerus, 142, 155
 Hamilton, for abduction at hip, 1049
 in synovitis of hip-joint, 371
 Harley's cross, in fracture of clavicle, 146
 Hawley, for fracture of femur, 196
 wire extension, for fracture of phalanges, 185
 Heusner's glue, in bone tuberculosis, 269
 Hodgen, for fracture of femur, 196
 internal angular, and traction in fracture of humerus, 155
 Jones's, in fracture of humerus, 155
 lateral wooden, in treatment of rachitic knock-knee, 1058
 Liston's long, modified, in knee-joint tuberculosis, 431
- Splint, metal, in bone tuberculosis, 269
 of Sinclair's glue in bone tuberculosis, 268
 palmar, for Bennett's fracture, 184
 fracture of forearm, 175
 phalanges, 185
 plaster of Paris, in fracture of forearm, 176
 in hip-joint tuberculosis, 412
 poroplastic in bone tuberculosis, 269
 right-angled antero-posterior, in fracture of elbow, 168
 forearm, 176
 Robinson's flask, for fracture of phalanges, 185
 Royston barrel stave, in fracture of clavicle, 145
 Schaffer's lateral traction, for fracture of femur, 189
 Sinclair, for fracture of forearm, 177
 Stimson's, for fracture of ankle-joint, 205
 straight posterior, in post-operative treatment of elbow-joint tuberculosis, 448
 suspension extension, for fracture of femur, 196
 or gallows, for fracture of femur, 192
 Thomas's arm, for fracture of forearm, 178
 humerus, 178
 hip, in correction of deformity associated with hip-joint tuberculosis, 414
 hip-joint tuberculosis, 413
 osteomyelitis of lower extremity, 236
 in obstetrical fracture of femur, 143
 knee, bed pattern, for fracture of femur, 194
 in knee-joint tuberculosis, 426
 in synovitis, 371
 traction, for fracture of forearm, 177
 tin, for fracture of phalanges of thumb, 185
 use of, for congenital talipes equinovarus, 1094
 Van der Veld, for fracture of forearm, 177
 wood, in bone tuberculosis, 269
- Sponge truss, 753
- Sprengel's shoulder, 988
- Staphylococcus pyogenes aureus in causation of acute infective synovitis, 365, 366
- Starvation, before anæsthesia, danger of, 75
- Status thymo-lymphaticus, 667
 diagnosis of, 669
 examination in, 668
 treatment of, 669
 surgical, 669

- Thymitis, acute 660
 Thyms gland 662
 acute oedema of 666
 atrophy of 663
 congenital absence of, 665
 embryology of 663
 enlargements of 660
 functions of, 664
 hemorrhage in 666
 hemorrhagic cysts of 666
 histology of 663
 hypoplasia of 665
 physiology of 664
 surgery of, 665
 surgical anatomy of, 662
 treatment of 667
 tumours of 666
 clinical features of 666
 Thyms parathyroid development of 662
 Thyroglossal cysts, 654
 treatment of 655
 duct development of 651
 developmental errors associated with 653
 fistulae treatment of 656
 varieties of 655
 sinus 655
 Thyroid extract in rickets 97
 gland deficiency diseases of 662
 dermoids of 662
 development of 651 656
 endothelioma of 661
 foetal adenomata of 660
 inflammatory processes of, 650
 perithelioma of 661
 sarcoma of 661
 surgical affections of 656
 teratomata of 662
 tuberculosis of 658
 tumours of 660 661
 lingual diagnosis of 653
 treatment of 654
 Thyroiditis acute 656
 treatment of 657
 tuberculous 657
 Tibia absence of congenital 1106
 acute osteomyelitis of 234
 congenital absence of 1104
 epiphysis of upper Osgood Schlatter's disease of 1069
 fractures of 198 204
 ante natal in child of three years 139
 oblique 202
 spiral 200
 sub periosteal 136
 transverse 191 201
 treatment of conditions for 201
 metaphysis of upper exostosis of 343
 periosteal sarcoma of 347 348
 shaft of tuberculous X ray appearance of 248
 tubercle of injury to 1067
 Tibia tuberculosis of, incidence of 216
 tuberculous osteomyelitis of 256
 upper metaphysis of, tuberculosis of X ray appearances 47
 Time, length of, of operation as cause of surgical shock 37
 Tissue staining in severe wounds 13
 Tissues adequate oxygenation of during operation importance of 77
 Toes contraction of congenital 1080
 gangrene of after scurvy 461
 Tongue 562
 lymphangioma of 563
 ulcers of 563
 Tongue tie 562
 Tonsillectomy guillotine method 591
 Tonsillitis 587
 quinsy complicating 588
 Tonsils, diseases of 586
 enlarged decubitus in 5
 hypertrophy of 589
 treatment of medical 596
 operative after treatment, 592
 complications of 592
 enucleation by dissection 591
 guillotine 591
 indications for 590
 in etiology of tuberculous cervical adenitis 629
 tuberculosis of 593
 tumours of 593
 Torticollis 626 (*see also* Wryneck)
 and Pott's disease differential diagnosis of, 304
 spastic 627
 Toxæmia stage of following burns and scalds 21
 Toxæmias and infections as indication for transfusion and infusion 52 53
 Trachea anatomical peculiarities of 593
 congenital malformations of 594
 foreign bodies in 595
 treatment of 595
 operations on 599
 Tracheotomy 601
 after treatment in 603
 for foreign bodies 595
 technique of 602
 varieties of 601
 Transfusion definition of 43
 of blood 56
 dangers of 56
 cardiac embarrassment during 63
 incompatibility the blood groups 56
 transmission of disease 62
 methods of comparison of 64
 anti coagulant blood, 64
 choice of 63
 Cries 64
 whole blood 63
 operative technique of, 63

- Syphilis, congenital, manifestations of,
 maternal history, 124
 prognosis of, 129
 treatment of, 130
 galyl in, results of, 135
 iodides in, 131
 mercurial, 130
 neo-salvarsan in, results of, 135
 novarsenobenzol (Billon) in, re-
 sults of, 135
 parental, 130
 results of, 134
 salvarsan in, 131
 dosage of, 131
 methods of administration of,
 131
 mortality from, 134
 recurrence of symptoms, 135
 results of, 134
 technique of injection, 133
 trypanimide in, 135
 in etiology of Perthe's disease, 1023
 Syphilitic and tuberculous joint disease,
 differential diagnosis of, 387
 Syringo-myelocoele, spinal, 701
- Tabes mesenterica, 809
 treatment, 810
- Talipes arcuatus, 1079
 calcaneus, Dunn's operation for
 correction of, 966
 Jones's operation for, 968
 operation for, result of, 966
 paralytic, of left foot, 965
 double paralytic, 960
 equino-cavus, paralytic, 958
 congenital, 1089
 double congenital, 1087
 equinus, paralytic, of left foot, 957
 spastic, 972, 977
 shoes, 1096
- Talma-Morrison operation in biliary
 cirrhosis, 866
- Tarsus, acute osteomyelitis of, 236
 tuberculosis of, 334
 incidence of, 246
- Teeth, affections of, in congenital
 syphilis, 128
 in etiology of tuberculous cervical
 adenitis, 629
- Temperature in physical examination, 8
- Tenderness in diagnosis of elbow-joint
 tuberculosis, 443
- Tendodesis, in paralytic deformities of
 ankle-joint, 969
- Tendons, fixation of, in paralytic de-
 formities of ankle-joint, 969
 lengthening of, in treatment of
 spastic paralysis, 980
 operations on, in spastic paralysis,
 980, 981
 transplantation of, in paralysis, 963
- Tenotomy in spastic paralysis, 980
 subcutaneous, for wryneck, 625
- Tension, intra-pleural, estimation of,
 in diagnosis of adhesive em-
 pyema, 681
- Teratoma, sacral, 693
- Teratomata of thyroid gland, 662
 of testis, 947
- Terrace method of treating hare-lip, 538
- Testis, descent of, foetal, 741, 742
 diseases of, 945
 left, imperfect descent of, 784
 misplaced, 783, 789
 torsion of, 944
 treatment of, 945
 tuberculosis of, 945
 tumours of, 947
 mixed, 947
 sarcomata, 947
 teratomata, 947
 treatment, 947
 undescended, 740, 783, 784
 and inguinal hernia, differential
 diagnosis of, 751
 complications of, 786
 diagnosis of, 786
 left, 786
 origin of, 784
 pathology of, 785
 treatment of, 787
 conservative, 787
 operative, 788
 results, 789
- Tête carrée, 466
- Thiersch skin grafts, after-treatment,
 30
 technique of, 29, 30
- Thomas arm splint, for fracture of
 forearm or humerus, 178
 hip splint in correcting deformity
 associated with hip-joint tu-
 berculosis, 414
 hip-joint tuberculosis, 413
 osteomyelitis of lower extremity,
 236
- knee splint, bed pattern, for fracture
 of femur, 194
 in knee-joint tuberculosis,
 426
 in synovitis of knee-joint, 371
- knock-knee brace, 1059
- splint in obstetrical fracture of femur,
 143
- traction splint, for fracture of fore-
 arm, 177
- wrench and orthopædic wedge for
 congenital talipes, 1097, 1098
- Thorax, changes in, in Potts' disease,
 286
 deformities of in rickets, 94
- Throat, affections of, 585
- Thumb, contraction deformity of,
 resulting from burn of palm, 27
- dislocation of, congenital, 1002
- terminal phalanx of, dislocation of,
 187

- Tuberculosis surgical, treatment of
general, heliotherapy. 114
 115
 light 114
 artificial, 115 116
 lamps for, 115
 sera in 120
 Spahlinger 120
 specific antigenic, 117
 tuberculin 117
 and vaccines combined 120
 local principles of 122
 prophylactic 112
 isolation of contacts 113
(see also under Organs and Regions)
- * Tuberculous dactylitis 330
 epiphyseal arthritis pathology of 290
- Tumours bladder 925
 cerebral causing hydrocephalus 490
 dermoid of mid line of back 694
 external ear 571
 kidney 893
 liver 896
 mixed of sacral region 693
 pre coccygeal cystic 695
 pre sacral cystic 695
 sacro coccygeal 693
 testis 947
 thymus 960
 thyroid gland 660
 tonsil 593
 vulva 876
- Tunica adventitia changes in in
 syphilis and tuberculosis 253
- Tunica vaginalis intermittent hydro
 cele of and inguinal hernia
 differential diagnosis of 751
- Two stage operation for cleft palate,
 558
- Tympanic membrane normal and
 pathological 573
- Typhoid fever and acute osteomyelitis,
 differential diagnosis of 226
 osteomyelitis 240
- Ulcer meatal complicating circum
 cision 930
 of frænum 563
- Ulna acute osteomyelitis of 237
 and radius combined fracture of 173
 club hand congenital 992
 defects of congenital 993
 pathology of 993
 treatment 994
 fracture of greenstick 172
 olecranon process of fracture of in
 injury of elbow 163
 shaft of fractures of 173
 treatment 174
 tuberculosis of with sequestrum
 formation 260
 tuberculosis of incidence of 246
 and new sub periosteal deposit
 261
- Ulna, upper end, tuberculosis of, 257,
 143
- Umbilical cord congenital hernia into
 773 776
- Umbilicus fistula of, 798
- Urachal cysts 910
 fistula 910
- Urates, excess of 912
- Ureter tuberculosis of, 887
- Urethra operations on in treatment
 of hypospadias 937
- Uric acid excess of 912
- Urine Bence-Jones bodies in, in diffuse
 myeloma, 350
 collection of 911
 coloured 913
 conditions of pathological 912
 contents of physiological clinical
 significance and influence of
 912
 examination of, before anaesthesia
 importance of 70
 enuresis 918
 pyelitis 892
 incontinence of 913, 921
 clinical conditions 913
 patho physiological basis of 914
 normal character of 911
 recovery of ventricular injection
 substance from, 497
 retention of 921
 secretion of in development of the
 kidney 885
- Vaccines and tuberculin combined in
 treatment of tuberculosis 120
- Van der Veld splint for fracture of
 forearm 177
- Ventricle lateral topography of 498
- Ventriculograms 501
- Ventriculography apparatus for 499
 position of head for 499
 technique of 497
- Vertebrae blood supply of 282
 changes in in Potts disease, 283
 portion of other than body tuber
 culosis of 290
 tuberculosis of 282 (*see also under*
 Potts disease)
 incidence of 246
- Vincent's angina 589
- Virchow's theory of polycystic kidney
 899
- Viscera affections of in congenital
 syphilis 128
 changes of in congenital syphilis 125
 in scoliosis 726
- Vitamine theory in etiology of rickets
 88
- Volkman Leser contracture,
 diagnosis of 1011
 pathology of 1011
 treatment of 1012
- Volvulus causes of 850

- Transfusion, citrated blood, 65
 donor for, collection of blood
 from, method of, 67
 instruments for, 65, 66
 recipient of, administration of
 blood to, method of, 68, 69
- Transfusions and infusions, 43
 fluids for, dextrose, solutions of,
 hypertonic, 48
 physiological, 48
 gum-saline solution, 46
 human blood, 43
 biological activator action
 of, 46
 capability of coagulation
 and of initiating clotting
 of, 45
 oxygen-carrying capacity
 of, 44
 physical properties of, 43
 serological properties of, 45
 sodium bicarbonate, solutions
 of, 49
 hypertonic solutions of, 47
 therapeutic actions of, 43
 in surgical shock, 41
 indications for, 49
 abnormal intracranial pressure:
 hypertension, 55
 hypotension, 56
 anæmias, 54
 burns and scalds, 52
 dehydration, 51
 hæmorrhage, 49
 hæmorrhagic diseases, 52
 marasmus, 54
 nephritis, 51
 pellagra, 55
 poisoning by coal-gas, 53
 nitro-benzol, 53
 septicæmias, 53
 shock, 50
 toxæmias and infections, 52, 53
 technique of, 56
- Trauma in etiology of joint tuber-
 culosis, 380
 Perthe's disease, 1022
 wryneck, 621
 local, and hip-joint tuberculosis,
 differential diagnosis of, 407
- Traumatic arthritis and acute infective
 synovitis, differential diag-
 nosis of, 367
 joint affections, 363
 lesions and tuberculosis of knee-
 joint, differential diagnosis of,
 423
- Trendelenberg's test for congenital
 dislocation of hip, 1032
- "Trident" hand in achondroplasia, 353
- Trusses, application of, 755
 in treatment of umbilical hernia,
 779
 varieties and methods, 753
- Trusses, measurements for, 754
 shaping of, 754
 sponge, 753
 varieties of, 754
 worsted, method of application, 753
- Trypsanamide in treatment of syphilis,
 135
- Trypsin treatment of bone tuber-
 culosis, 271
- Tubercle bacilli, bone changes caused
 by, 249
- Tuberculin, administration of, methods
 of, 119
 cutaneous, 118
 oral, 119
 percutaneous, 118
 subcutaneous, 118
 and vaccines combined in treatment
 of tuberculosis, 120
 autogenous, 119
 Bereneck's, 119
 human and bovine, comparison of,
 119
 introduced into body, effects of, 117
 Koch's old, 118
 tests, focal, 110
 local, 109
 Moro reaction, 110
 ophthalmo-reaction (Calmette),
 110
 Von Pirquet's cutaneous test,
 110
 treatment of tuberculosis, 117
 of tuberculous cervical adenitis,
 642
 varieties of, 117
 choice of, 119
- Tuberculosis, encysted, of bone, 249
 infiltrating, of bone, 249
 of bones, 244
 surgical, 103
 clinical features of, 108
 diagnosis of, 109
 by serological tests, 111
 by tuberculin tests, 109
 factors controlling origin of, 103
 bovine and human types,
 statistics of, 104
 relative importance
 of, 103
 inheritance, 105
 portals of entry, 104
 resistance of child and its
 tissues, 106
 general, 108
 immunity in, 106
 incidence of, 103
 pathology of, 106
 prognosis of, factors governing, 111
 treatment of, 112
 general, 113
 chemotherapy in, 121
 climate, 113
 Droyer's vaccine in, 120

Messrs. Edward Arnold & Co's

Medical Publications

SURGERY

TEXT-BOOK OF SURGICAL DIAGNOSIS Edited by A J WALTON
MS FRCS In two volumes Medium 8vo xvi + 1121 pages, with 570 illustrations 63 net

THE PRACTICE OF SURGERY By RUSSELL HOWARD CBE MS
(LOND) FRCS (ENG) Third Edition With 8 coloured plates and 523 illustrations Medium 8vo viii + 1280 pages 30s net

THE HOUSE SURGEON'S VADE-MECUM By RUSSELL HOWARD
CBE, MS FRCS and ALAN C PERRY MB MS, FRCS Second Edition
Crown 8vo viii + 520 pages and 159 illustrations 12s 6d net

SURGICAL EMERGENCIES By RUSSELL HOWARD CBE MS
FRCS Crown 8vo viii + 216 pages and 45 illustrations 7s 6d net

A POCKET SURGERY By D C L FITZWILLIAMS CMG MD CHM
FRCS Crown 8vo viii + 348 pages 10s 6d net

SURGICAL MATERIALS AND THEIR USES By ALEXANDER
MACLENNAN MB CM (GLAS) Crown 8vo viii + 252 pages With 277 diagrams
and illustrations 4s 6d net

MODERN ANESTHETICS By J F W SILK MD SECOND EDITION
Crown 8vo xii + 192 pages 37 illustrations 7s 6d net

TEXT BOOK OF THE SURGICAL DYSPEPSIAS By A J WALTON
MS FRCS Surgeon Large Demy 8vo xii + 728 pages 272 illustrations
and 2 coloured plates 4s net

FRACTURES AND SEPARATED EPIPHYSES By A J WALTON
MS FRCS Demy 8vo viii + 288 pages With 101 illustrations 10s 6d
net.

**A GUIDE TO THE DISEASES OF THE NOSE AND THROAT, AND
THEIR TREATMENT** By CHARLES A PARKER FRCS and LIONEL
COLLEDGE FRCS MB (CAMP) SECOND EDITION Demy 8vo xvi + 584
pages With 241 illustrations 25s net

CONTRIBUTIONS TO ABDOMINAL SURGERY By the late
HAROLD L BARNARD MS FRCS Edited by JAMES SHERREN FRCS Demy
8vo xx + 392 pages With 65 illustrations 16s net

BLOOD-VESSEL SURGERY AND ITS APPLICATION By
CHARLES CLAUDE GUTHRIE MD PhD Demy 8vo xvi + 360 pages With
158 illustrations 13s net

ORTHOPEDICS FOR PRACTITIONERS An Introduction to the
Practical Treatment of the Common Deformities By PAUL B ROTH
MB ChB (ABERD) FRCS (ENG) Demy 8vo xii + 196 pages With 57
illustrations 10s 6d net.

LONDON EDWARD ARNOLD & CO 41 & 43 MADDOX ST W 1

- Volvulus, exciting, 851
 clinical features of, 851
 diagnosis of, 852
 etiology of, 850
 of the intestine, 850
 pathology of, 851
 treatment of, 852
 Vomiting, cyclic, and appendicitis,
 differential diagnosis of, 832
 post-anæsthetic, treatment of, 81
 Von Pirquet's cutaneous test, 110
 Vulva, tumours of, 876
- Wassermann complement fixation test
 in syphilis, 129
 Wasting in diagnosis of shoulder-joint
 tuberculosis, 438
 Water, injection of, in treatment of
 intussusception, 847
 Wax in ear, 570
 Whitman's operation for obstetrical
 paralysis of upper arm, 1009
 stretcher frame, for paralysis in
 Potts' disease, 321
 in treatment of Potts' disease,
 308
 support for flat foot, 1074
 Winkel's disease, 866
 Wolff's law of bone transformation, 95
 Wood splints in bone tuberculosis, 269
 Worsted truss, application of, 753
 Wounds and contusions, 12
 minor, simple remedies for, 12
 operation, 17
 severe, antitetanic serum in, 12
 treatment of, rubber-protected
 stitches in, value of, 16
 secondary suture of, 15
 importance of microbic
 count in, 16
 special methods of, 12, 13
 primary suture, 13
 Wright's treatment of tuberculous
 sinuses, 281
 Wrist-joint, acute infective synovitis
 of, 373
 dislocation of, congenital, 1000
 subluxation of, spontaneous, 1001
 tuberculosis of, 448
 pathology of, 448
 treatment of by Bier's congestive
 method, 449
 complete fixation, 449, 450
 conservative, 449
 convalescent, 450
 injection, 449
 operative, 450
 Wryneck, 620
 acute, 627
 Wryneck, acute, and Potts' disease,
 differential diagnosis of, 304
 congenital, 620
 clinical features of, 623
 diagnosis of, 624
 etiology of, 621
 pathology of, 623
 treatment of, 625
 operative, 625
 after-treatment in, 626
 varieties of, rare, 627
 definition of, 620
 double, 627
 lateral, 627
 posterior, 627
 spasmodic, 627
 treatment of, 628
 varieties of, 620
 X-ray appearances at different stages
 of joint tuberculosis, 384
 diagnosis of achondroplasia, 353
 adhesions in empyema, 681
 ankle-joint fractures, 205
 branchial fistulae, 611
 congenital dislocation of hip, 1033
 empyema, 679
 foreign bodies in larynx and
 trachea, 595
 fracture of fibula, 201
 head injury, 514
 joint tuberculosis, 382, 384, 387,
 405, 422, 439
 Perthe's disease, 1022
 Potts' disease, 302
 proliferative arthritis deformans,
 457
 retro-pharyngeal abscess, 566
 scoliosis, 728
 separation of upper epiphysis of
 humerus, 152
 spina bifida, 707
 status thymo-lymphaticus, 669
 synovitis of hip-joint, 371
 traumatic joint affection, 364
 tuberculosis of os calcis, 334
 tuberculous dactylitis, 332
 examination of abdomen and
 mediastinum in tuberculous
 cervical adenitis, 637
 treatment combined with complete
 fixation in bone tuberculosis,
 271
 spleen in lymphatic leukaemia, 460
 status thymo-lymphaticus, 669
 tuberculous cervical adenitis, 641
- Young's method of recording spinal
 deformity, 298
 Youth, syphilitic synovitis of, 452

Messrs. Edward Arnold & Co's

Medical Publications

SURGERY

TEXT-BOOK OF SURGICAL DIAGNOSIS Edited by A J WALTON
MS FRCS In two volumes Medium 8vo xvi + 1121 pages with 570 illustrations 63s net

THE PRACTICE OF SURGERY By RUSSELL HOWARD CBE MS
(LOND) FRCS (ENG) THIRD EDITION With 8 coloured plates and 523 illustrations Medium 8vo viii + 1280 pages 30s net

THE HOUSE SURGEON'S VADE MECUM By RUSSELL HOWARD
CBE MS FRCS and ALAN C PERRY, MB MS FRCS SECOND EDITION
Crown 8vo viii + 50 pages and 159 illustrations 12s 6d net

SURGICAL EMERGENCIES By RUSSELL HOWARD CBE, MS
FRCS Crown 8vo viii + 216 pages and 45 illustrations 7s 6d net

A POCKET SURGERY By D C L FITZWILLIAMS CMG MD CHM
FRCS Crown 8vo viii + 348 pages 10s 6d net

SURGICAL MATERIALS AND THEIR USES By ALEXANDER
MACLENNAN MB, CM (GLAS) Crown 8vo viii + 252 pages With 277 diagrams
and illustrations 4s 6d net

MODERN ANÆSTHETICS By J F W SILK MD SECOND EDITION
Crown 8vo xvi + 192 pages 37 illustrations 7s 6d net

TEXT BOOK OF THE SURGICAL DYSPEPSIAS By A J WALTON
MS FRCS Surgeon Large Demy 8vo xii + 728 pages 272 illustrations
and 2 coloured plates 42s net

FRACTURES AND SEPARATE EPIPHYSES By A J WALTON
MS FRCS Demy 8vo viii + 288 pages With 101 illustrations 10s 6d
net

**A GUIDE TO THE DISEASES OF THE NOSE AND THROAT AND
THEIR TREATMENT** By CHARLES A PARKER FRCS and LIONEL
COLLEGE FRCS MB (CANT) SECOND EDITION Demy 8vo xvi + 584
pages With 241 illustrations 25s net

CONTRIBUTIONS TO ABDOMINAL SURGERY By the late
HAROLD L BARNARD MS FRCS Edited by JAMES SHERREN FRCS Demy
8vo xx + 390 pages With 65 illustrations 16s net

BLOOD-VESSEL SURGERY AND ITS APPLICATION By
CHARLES CLAUDE GUTHRIE MD PhD Demy 8vo xvi + 350 pages With
158 illustrations 15s net

ORTHOPEDICS FOR PRACTITIONERS An Introduction to the
Practical Treatment of the Common Deformities By PAUL B ROTH
MB CHB (ABERD) FRCS (ENG) Demy 8vo xii + 196 pages With 57
illustrations 10s 6d net

LONDON EDWARD ARNOLD & CO 41 & 43 MADDOX ST W 1
M 4

OPHTHALMOLOGY

THE ROUTINE EXAMINATION OF THE EYE. By BASIL T. LANG, M.A., F.R.C.S. Crown 8vo. 152 pages. 30 illustrations. 6s. net.

GLAUCOMA. An Enquiry into the Physiology and Pathology of the Intra-Ocular Pressure. By THOMSON HENDERSON, M.D. (EDIN.). Demy 8vo. xvi + 222 pages. With 62 illustrations. 10s. 6d. net.

COLOUR VISION. A Discussion of the Leading Phenomena and their Physical Laws. By W. PEDDIE, D.Sc., F.R.S.E. Demy 8vo. xii + 208 pages. Illustrated. 12s. 6d. net.

GYNÆCOLOGY AND OBSTETRICS

MIDWIFERY. Edited by COMYNS BERKELEY, M.A., M.D., M.C., F.R.C.P.; H. RUSSELL ANDREWS, M.D., B.S., F.R.C.P.; and J. S. FAIRBAIRN, M.A., B.M., B.C., F.R.C.P. THIRD EDITION. Medium 8vo. xii + 780 pages. With 4 coloured plates and 301 illustrations. 24s. net.

DISEASES OF WOMEN. Edited by COMYNS BERKELEY, H. RUSSELL ANDREWS and J. S. FAIRBAIRN. FOURTH EDITION. Completely revised and largely rewritten. Medium 8vo. xii + 580 pages. With 8 coloured plates and 186 illustrations.

A MANUAL OF GYNÆCOLOGY for Students and Practitioners. By SAMUEL J. CAMERON, M.B., CH.B. (GLAS.), F.R.F.P. & S.G. THIRD EDITION. Medium 8vo. xx + 652 pages. With 274 original illustrations, many of them coloured. 25s. net.

A GLASGOW MANUAL OF OBSTETRICS. By SAMUEL J. CAMERON, M.B., F.R.F.P. & S.G.; ARCHIBALD N. McLELLAN, M.B. (GLAS.), L.M. (DUBLIN); ROBERT A. LENNIE, M.B. (GLAS.); and JOHN HEWITT, M.B. (GLAS.). Medium 8vo. xvi + 574 pages. 214 illustrations. 21s. net.

UTERINE HÆMORRHAGE. By SAMUEL J. CAMERON, M.B. (GLAS.), F.R.F.P. & S.G., and JOHN HEWITT, M.B. (GLAS.). Crown 8vo. viii + 200 pages. 8s. 6d. net.

DIFFICULT LABOUR. By SAMUEL J. CAMERON, M.B. (GLAS.), F.R.F.P. & S.G., and JOHN HEWITT, M.B. (GLAS.). Crown 8vo. xii + 336 pages. Illustrated. 10s. 6d. net.

THE TREATMENT OF COMMON FEMALE AILMENTS. By FREDERICK JOHN McCANN, M.D., M.R.C.P., F.R.C.S. Demy 8vo. 8s. 6d. net.

A SYNOPSIS OF GYNÆCOLOGY. By ARTHUR GRAY, F.R.C.S., M.R.C.P. Crown 8vo. viii + 352 pages. 10s. 6d. net.

DISEASES OF CHILDREN

SURGERY OF CHILDHOOD. By JOHN FRASER, M.C., M.D., CH.M., F.R.C.S.E. In two volumes. Medium 8vo. xii + 1154 pages. 598 original illustrations. 42s. net.

LECTURES ON DISEASES OF CHILDREN. By ROBERT HUTCHISON, M.D. (EDIN.), F.R.C.P. FIFTH EDITION. Demy 8vo. xii + 460 pages. Fully illustrated. 21s. net.

LONDON: EDWARD ARNOLD & CO., 41 & 43 MADDOX ST., W.1.

DISEASES OF CHILDREN SECOND EDITION Edited by HUGH THURSFIELD DM, FRCP and D PATERSON MD MRCP First edition edited by ARCHIBALD L GARROD KC MG IRS the late FREDERICK E BATTEN MD FRCP, and HUGH THURSFIELD DM FRCP In one volume Super Royal 8vo xvi + 1106 pages with 203 illustrations 45s net

THE INFANT Nutrition and Management By G ERIC PRITCHARD MA MD (Oxon) MRCP (Lond) THIRD IMPRESSION viii + 265 pages Crown 8vo 5s net

CLINICAL MEDICINE AND DIAGNOSIS

A SYSTEM OF CLINICAL MEDICINE Dealing with Diagnosis, Prognosis and Treatment of Disease By THOMAS DIXON SAVILL MD (Lond) EIGHTH EDITION Completely revised With 4 coloured plates and 170 illustrations

THE METHODS OF CLINICAL DIAGNOSIS By ALEXANDER GEORGE GIBSON MD FRCP, and WILLIAM TREGONWELL COLLIER MD, MRCP Crown 8vo viii + 398 pages 4 coloured plates and 136 illustrations 12s 6d net

TABULAR DIAGNOSIS By RALPH WINNINGTON LEFTWICH MD Crown 8vo vi + 359 pages 7s 6d net

MEDICAL CASE-TAKING A Guide for Clinical Clerks By A MILLS KENNEDY, MD (Glas) Crown 8vo 148 pages 5s net

PATHOLOGY

TEXT-BOOK OF PATHOLOGY By ROBERT MUIR MA MD ScD FRCS SECOND EDITION Medium 8vo viii + 872 pages 501 original illustrations 35s net

TEXT BOOK OF GENERAL PATHOLOGY Edited by M S PENNEY MA, MD FRCS and J RITCHIE MA MD Demy 8vo xii + 774 pages with 40 illustrations 21s net

TEXT BOOK OF SURGICAL PATHOLOGY By C JENNINGS MARSHALL MD MS FRCS and ALFRED PINEY MD ChB (Birm) MRCP, MRCS Demy 8vo viii + 470 pages 173 original illustrations 21s net

DISEASES OF THE NERVOUS SYSTEM

THE DIAGNOSIS OF NERVOUS DISEASES By SIR JAMES PURVES STEWART KC MG CB MD (Edin) FRCP SIXTH EDITION Medium 8vo viii + 648 pages with 285 illustrations 30s net

MODERN PROBLEMS IN NEUROLOGY By S A KINNIER WILSON MD FRCP Demy 8vo viii + 364 pages with 56 illustrations 21s net

THE COMMON NEUROSES Their Treatment by Psychotherapy By T A ROSS, MD, FRCP Demy 8vo xii + 256 pages 12s 6d net

THE BRAIN IN HEALTH AND DISEASE By JOSEPH SHAW BOLTON MD DSc (Lond) FRCP Medium 8vo xiv + 480 pages, with 99 illustrations 18s net

OPHTHALMOLOGY

THE ROUTINE EXAMINATION OF THE EYE. By BASIL T. LANG, M.A., F.R.C.S. Crown 8vo. 152 pages. 30 illustrations. 6s. net.

GLAUCOMA. An Enquiry into the Physiology and Pathology of the Intra-Ocular Pressure. By THOMSON HENDERSON, M.D. (EDIN.). Demy 8vo. xvi + 222 pages. With 62 illustrations. 10s. 6d. net.

COLOUR VISION. A Discussion of the Leading Phenomena and their Physical Laws. By W. PEDDIE, D.Sc., F.R.S.E. Demy 8vo. xii + 208 pages. Illustrated 12s. 6d. net.

GYNÆCOLOGY AND OBSTETRICS

MIDWIFERY. Edited by COMYNS BERKELEY, M.A., M.D., M.C., F.R.C.P.; H. RUSSELL ANDREWS, M.D., B.S., F.R.C.P., and J. S. FAIRBAIRN, M.A., B.M., B.C., F.R.C.P. THIRD EDITION. Medium 8vo. xii + 780 pages. With 4 coloured plates and 301 illustrations. 24s. net.

DISEASES OF WOMEN. Edited by COMYNS BERKELEY, H. RUSSELL ANDREWS and J. S. FAIRBAIRN. FOURTH EDITION. Completely revised and largely rewritten. Medium 8vo. xii + 580 pages. With 8 coloured plates and 186 illustrations.

A MANUAL OF GYNÆCOLOGY for Students and Practitioners. By SAMUEL J. CAMERON, M.B., CH.B. (GLAS.), F.R.F.P. & S.G. THIRD EDITION. Medium 8vo. xx + 652 pages. With 274 original illustrations, many of them coloured. 25s. net.

A GLASGOW MANUAL OF OBSTETRICS. By SAMUEL J. CAMERON, M.B., F.R.F.P. & S.G.; ARCHIBALD N. McLELLAN, M.B. (GLAS.), L.M. (DUBLIN); ROBERT A. LENNIE, M.B. (GLAS.); and JOHN HEWITT, M.B. (GLAS.). Medium 8vo. xvi + 574 pages. 214 illustrations. 21s. net.

UTERINE HÆMORRHAGE. By SAMUEL J. CAMERON, M.B. (GLAS.), F.R.F.P. & S.G., and JOHN HEWITT, M.B. (GLAS.). Crown 8vo. viii + 200 pages. 8s. 6d. net.

DIFFICULT LABOUR. By SAMUEL J. CAMERON, M.B. (GLAS.), F.R.F.P. & S.G., and JOHN HEWITT, M.B. (GLAS.). Crown 8vo. xii + 336 pages. Illustrated. 10s. 6d. net.

THE TREATMENT OF COMMON FEMALE AILMENTS. By FREDERICK JOHN McCANN, M.D., M.R.C.P., F.R.C.S. Demy 8vo. 8s. 6d. net.

A SYNOPSIS OF GYNÆCOLOGY. By ARTHUR GRAY, F.R.C.S., M.R.C.P. Crown 8vo. viii + 352 pages. 10s. 6d. net.

DISEASES OF CHILDREN

SURGERY OF CHILDHOOD. By JOHN FRASER, M.C., M.D., CH.M., F.R.C.S.E. In two volumes. Medium 8vo. xii + 1154 pages. 598 original illustrations. 42s. net.

LECTURES ON DISEASES OF CHILDREN. By ROBERT HUTCHISON, M.D. (EDIN.), F.R.C.P. FIFTH EDITION. Demy 8vo. xii + 460 pages. Fully illustrated. 21s. net.

LONDON: EDWARD ARNOLD & CO., 41 & 43 MADDOX ST., W.1.

A GUIDE TO URINARY DISEASES By A ABRAHAM OBE MD MRCP and A CLIFFORD MORSON, OBE, FRCS, etc. Demy 8vo 9s net

DIABETES ITS PATHOLOGICAL PHYSIOLOGY By J R MACLEOD, MB ChB DPH Illustrated xii + 224 pages 10s 6d net.

GLYCOSURIA AND ALLIED CONDITIONS By P J CAMMIDGE MD (LOND) Demy 8vo viii + 468 pages 18s net

MOVABLE KIDNEY Its Pathology, Symptoms and Treatment By HAROLD W WILSON, MS, FRCS and C M HINDS HOWELL, MD FRCP Demy 8vo viii + 104 pages Illustrated 4s 6d

THE CHEMICAL INVESTIGATION OF GASTRIC AND INTESTINAL DISEASES BY THE AID OF TEST MEALS By VAUGHAN HARLEY MD (EDIN) MRCP FCS and FRANCIS W GOODBODY, MD, MRCP Demy 8vo viii + 262 pages 8s 6d net

MEDICAL DISEASES OF THE WAR By ARTHUR F HURST MA MD (OXON) FRCP SECOND EDITION Demy 8vo viii + 320 pages Illustrated 12s 6d net.

OLD AGE Its Care and Treatment in Health and Disease By R SAUNDY MD SECOND IMPRESSION Demy 8vo viii + 312 pages 8s 6d net.

BACTERIOLOGY, HYGIENE AND SANITATION

PRINCIPLES OF BACTERIOLOGY AND IMMUNITY By W W C TOPLEY FRCP and G S WILSON, MD In two volumes Super royal 8vo Vol I xvi + 587 + xvi pages Vol II viii + 713 + xx pages with 242 diagrams 50s net per set.

HEALTH AND ENVIRONMENT By LEONARD HILL MB FRS and ARGYLL CAMPBELL MD, DSc Demy 8vo xii + 208 pages, with 8 plates 1.8 6d net

CHEMICAL DISINFECTION AND STERILIZATION By SAMUEL RIDEAL DSc FIC and ERIC K RIDEAL MA DSc FIC Demy 8vo viii + 314 pages 21s net

THE SANITARY OFFICER'S HANDBOOK OF PRACTICAL HYGIENE By Major General Sir W O BEVERIDGE CB CBE DSO DPH RAMC and C F WAINHILL Lieut Colonel RAMC MRCS, LRCP SECOND EDITION Crown 8vo viii + 236 pages 6s net

MILITARY HYGIENE AND SANITATION By Colonel CHARLES H MELVILLE CMG MB DPH Demy 8vo viii + 416 pages Illustrated. 16s net

MEDICAL JURISPRUDENCE

MEDICO-LEGAL INJURIES By ARCHIBALD MCKENDRICK FRCS (EDIN) Demy 8vo viii + 34. pages with 65 photographs and diagrams 18s net

FORENSIC CHEMISTRY By A LUCAS OBE FIC Demy 8vo viii + 268 pages 15s net.

LONDON EDWARD ARNOLD & CO 41 & 43 MADDOX ST W 1

DISEASES OF THE DIGESTIVE SYSTEM

A MANUAL OF DISEASES OF THE STOMACH. By WILLIAM MACLENNAN, M.B., C.M., assisted by J. SALISBURY CRAIG, M.B. Demy 8vo. xii + 392 pages, with 31 illustrations. 21s. net.

ULCER OF THE STOMACH. By CHARLES BOLTON, C.B.E., M.D., D.Sc. (LOND.), F.R.C.P., F.R.S. xvi + 396 pages, with 35 full-page plates. 15s. net.

LECTURES ON DYSPEPSIA. By ROBERT HUTCHISON, M.D., F.R.C.P. SECOND EDITION. Crown 8vo. 193 pages 6s. net.

INDIGESTION. Dr. G. Herschell's Text-Book. FOURTH EDITION. Revised and Re-written by ADOLPHE ABRAHAMS, O.B.E., M.D., M.R.C.P., etc. Demy 8vo. viii + 228 pages. 10s. 6d. net.

COOKERY FOR DYSPEPTICS. By the late Dr. GEORGE HERSCHELL. 2s. 6d. net.

OCCUPATIONAL DISEASES

LEAD POISONING AND LEAD ABSORPTION. By SIR THOMAS LEGGE, C.B.E., M.D., and SIR K. W. GOADBY, K.B.E., M.R.C.S., D.P.H. (CAMB.). Demy 8vo. xii + 308 pages, with 4 plates and 15 diagrams. 12s. 6d. net.

INDUSTRIAL POISONING. Translated from Dr Rambousek's "Gewerbliche Vergiftungen" by SIR THOMAS LEGGE, C.B.E., M.D. Demy 8vo. xii + 360 pages, with 60 illustrations. 14s. net.

CAISSON SICKNESS and the Physiology of Work in Compressed Air. By LEONARD HILL, M.B., F.R.S. Demy 8vo. xii + 256 pages. 10s. 6d. net.

VARIOUS DISEASES

PULMONARY TUBERCULOSIS. By G. T. HEBERT, M.A., M.D. (Oxon), M.R.C.P. (LOND.). Crown 8vo. viii + 212 pages. Illustrated. 7s. 6d. net.

DISEASES OF THE HEART. By JOHN COWAN, D.Sc., M.D., F.R.F.P.S., and W. T. RITCHIE, O.B.E., M.D., F.R.C.P.E., F.R.S.E. SECOND EDITION. Demy 8vo. xvi + 596 pages, with 321 illustrations. 30s.

THE TREATMENT OF DISEASES OF THE SKIN. By W. KNOWSLEY SIBLEY, M.A., M.D., B.Ch. (CAMB.), M.R.C.P., M.R.C.S. THIRD EDITION. Demy 8vo. iv + 248 pages, with 24 plates. 12s. 6d. net.

THE PARATHYROID GLANDS IN RELATION TO DISEASE. By H. W. C. VINES, M.A., M.D. Demy 8vo. 136 pages. Illustrated with 10 charts. 10s. 6d. net.

THE CARRIER PROBLEM IN INFECTIOUS DISEASE. By J. C. G. LEDINGHAM, C.M.G., M.B., D.Sc., and J. A. ARKWRIGHT, M.D., F.R.C.P. Demy 8vo. viii + 320 pages. 12s. 6d. net.

SYPHILIS: A Systematic Account of Syphilis from the Modern Standpoint. By JAMES MACINTOSH, M.D. (ABERD.), and PAUL FILDES, O.B.E., M.B., B.Ch. (CAMB.). Demy 8vo. xvi + 228 pages. Illustrated. 10s. 6d. net.

LONDON: EDWARD ARNOLD & CO., 41 & 43 MADDOX ST., W.1.

APPLIED PHYSIOLOGY A Handbook for Students of Medicine
By ROBERT HUTCHISON M.D., FRCP Crown 8vo xii + 298 pages Illustrated 7s 6d net

MANUAL OF HUMAN PHYSIOLOGY By LEONARD HILL M.B.
FRS Crown 8vo xii + 484 pages with 177 illustrations 6s net

FURTHER ADVANCES IN PHYSIOLOGY Edited by LEONARD HILL
M.B., FRS Demy 8vo viii + 440 pages Illustrated 16s net.

PHYSIOLOGY FOR DENTAL STUDENTS By A. C. CURZON MILLER,
B.Sc. L.M.S.S.A., F.C.S. Demy 8vo viii + 206 pages, with 81 illustrations.
10s 6d net

PHYSIOLOGY FOR NURSES By W. B. DRUMMOND M.D. FRCP
(Edin.) Crown 8vo xii + 210 pages 81 illustrations 2s 6d net

PHYSIOLOGY OF THE SPECIAL SENSES By M. GREENWOOD
MRCS MRCP F.S.S. Demy 8vo viii + 240 pages 28 illustrations
10s 6d net.

THE BODY AT WORK A Treatise on the Principles of Physiology.
By ALEX. HILL M.A. M.D. FRCS Demy 8vo xii + 446 pages, with 46 illustrations 16s. net.

INTERNAL SECRETION AND THE DUCTLESS GLANDS By
SWALE VINCENT M.D. (Lond.) D.Sc. (Edin.) MRCS MRCP, FRS (Edin.),
FRS (CANADA) THIRD EDITION Demy 8vo xvi + 463 pages and 112 illustrations 25s net.

AN INTRODUCTION TO THE STUDY OF SECRETION By SWALE
VINCENT M.D. Demy 8vo xii + 168 pages and 35 illustrations 10s 6d net

PRACTICAL PHYSIOLOGY By E. P. CATHCART M.D. D.Sc. FRS,
D. N. PATON M.D. FRCP (Edin.) FRS, and M. S. PENBREY M.A. M.D.,
FRS THIRD EDITION Demy 8vo xii + 408 pages 213 illustrations 18s
net

PRACTICAL CHEMICAL PHYSIOLOGY By W. W. TAYLOR M.A.
D.Sc. Crown 8vo 71 pages ORDINARY EDITION 4s 6d net, INTERLEAVED
EDITION 5s net

BIO CHEMISTRY A Study of the Origin, Reactions, and Equilibria
of Living Matter By the late BENJAMIN MOORE M.A. D.Sc. FRS
Demy 8vo viii + 340 pages 21s net

A LABORATORY HANDBOOK OF BIO CHEMISTRY By P. C.
RAIMENT B.A. (Oxon) MRCS LRCP, and G. L. PESKETT B.A. Crown 8vo
102 pages. 5s net

**PHYSICAL CHEMISTRY ITS BEARING ON BIOLOGY AND
MEDICINE** By J. C. PHILIP OBE M.A. D.Sc. FRS THIRD EDITION
Crown 8vo viii + 367 pages. 23 illustrations. 8s 6d net

**THE CHEMISTRY OF COLLOIDS AND SOME TECHNICAL APPLI-
CATIONS** By W. W. TAYLOR M.A. D.Sc. SECOND EDITION Crown
8vo viii + 332 pages. 10s. 6d net.

PHARMACOLOGY AND THERAPEUTICS

A MANUAL OF PHARMACOLOGY. By WALTER E. DIXON, M.A., M.D., B.S., B.Sc., D.P.H., F.R.S. SEVENTH EDITION. Demy 8vo. xii + 486 pages, with 97 illustrations. 18s. net.

A TEXT-BOOK OF MEDICAL TREATMENT. (Alphabetically arranged.) By WILLIAM CALWELL, M.D. Royal 8vo. iv + 630 pages. 16s. net.

PSYCHOLOGY AND PSYCHO-THERAPY. By WILLIAM BROWN, M.D., D.Sc., M.R.C.P. SECOND IMPRESSION. Crown 8vo. 8s. 6d. net.

FOOD AND THE PRINCIPLES OF DIETETICS. By ROBERT HUTCHISON, M.D. (Edin.), F.R.C.P. SIXTH EDITION. Demy 8vo. xx + 610 pages, with 33 illustrations. 21s. net.

THE PROTEIN ELEMENT IN NUTRITION. By D. McCAY, M.D., B.Ch., B.A.O., M.R.C.P. (Lond), Lt.-Col. I.M.S. Demy 8vo. xvi + 216 pages. Illustrated. 10s. 6d. net.

SUNSHINE AND OPEN-AIR. Their Influence on Health, with special Reference to the Alpine Climate. By LEONARD HILL, M.B., F.R.S. SECOND EDITION. Demy 8vo. 140 pages, with 12 illustrations and 8 plates 10s. 6d. net.

LIGHT TREATMENT IN SURGERY. By Dr. O. BERNHARD (St. Moritz). Translated from the Second German Edition, with fresh notes by the author, by R. KING-BROWN, B.A., M.D., D.P.H. Medium 8vo. xii + 317 pages, 105 illustrations 21s. net.

ANATOMY AND ANTHROPOLOGY

PRACTICAL ANATOMY: The Students' Dissecting Manual. By F. G. PARSONS, F.R.C.S. (Eng.), etc.; and WILLIAM WRIGHT, M.B., D.Sc., F.R.C.S. (Eng.). In two volumes, with 332 illustrations. 12s. 6d. net each.

HUMAN EMBRYOLOGY AND MORPHOLOGY. By Sir ARTHUR KEITH, M.D., F.R.C.S., F.R.S. FOURTH EDITION. Demy 8vo. viii + 492 pages 490 illustrations. 30s. net.

ARBOREAL MAN. By F. Wood JONES, F.R.S. Demy 8vo. x + 224 pages, with 81 illustrations and diagrams. 8s. 6d. net.

THE MATRIX OF THE MIND. By F. Wood JONES, F.R.S., and S. D. PORTEUS. Demy 8vo. viii + 424 pages, with 80 illustrations 21s. net.

MAN'S PLACE AMONG THE MAMMALS. By F. Wood JONES, F.R.S. Demy 8vo. viii + 372 pages, with 160 diagrams and 12 plates 21s. net.

AN INTRODUCTION TO PHYSICAL ANTHROPOLOGY. By E. P. STRIBBE, F.R.C.S. Demy 8vo. With 12 illustrations. *[In the Press]*

PHYSIOLOGY

A TEXT-BOOK OF PHYSIOLOGY. By H. E. ROAF, D.Sc. (LIVERPOOL), M.R.C.S., L.R.C.P. Demy 8vo. viii + 606 pages, with 325 illustrations. 25s. net.

CLINICAL PHYSIOLOGY. By R. J. S. McDOWALL, D.Sc., M.B., F.R.C.P. (Edin.). With an Introduction by W. D. HALLIBURTON, LL.D., F.R.C.P., F.R.S. Demy 8vo. viii + 422 pages, with 4 plates. 21s. net.

LONDON: EDWARD ARNOLD & CO., 41 & 43 MADDUX ST., W.1.

BIOLOGY

AN INTRODUCTION TO THE STUDY OF THE PROTOZOA. With special reference to the Parasitic Forms. By the late E. A. MINCHIN, M.A., Ph.D., F.R.S. NEW IMPRESSION. Demy 8vo. xii + 520 pages 194 diagrams. 25s. net.

GROWTH. By G. R. DE BEER, B.A., B.Sc., F.L.S. Demy 8vo viii + 120 pages, with 8 plates and other diagrams. 7s. 6d. net.

THE PROGRESS OF LIFE: A Study in Psychogenetic Evolution. By A. MEEK, F.L.S., F.Z.S. Demy 8vo. [In the Press.]

THE MECHANISM OF LIFE. In Relation to Modern Physical Theory. By JAMES JOHNSTONE, D.Sc. Demy 8vo. xii + 248 pages, with 53 diagrams. 15s. net.

PROCEEDINGS OF THE WORLD POPULATION CONFERENCE, 1927. Edited by MARGARET SANGER. Medium 8vo. 383 pages. 20s net

DENTISTRY

OPERATIVE DENTAL SURGERY. By J. B. PARFITT, L.R.C.P., M.R.C.S., L.D.S. SECOND EDITION. Demy 8vo. viii + 342 pages. Fully illustrated. 21s net.

A TEXT-BOOK OF SURGERY FOR DENTAL STUDENTS. By G. P. MILLS, M.B., B.Sc. (LOND.), F.R.C.S., and H. HUMPHREYS, M.B., Ch.B., B.D.S. (BIRM.), L.D.S. (ENG.). THIRD EDITION. Demy 8vo. xii + 344 pages, with 57 illustrations. 14s. net.

A TEXT-BOOK OF DENTAL ANATOMY AND PHYSIOLOGY. By JOHN HUMPHREYS, M.D.S. (BIRM.), F.S.A., F.G.S., F.L.S., and A. W. WELLINGS, M.D.S. (BIRM.), L.D.S. (EDIN.). Demy 8vo. viii + 323 pages. 254 illustrations. 16s. net.

DENTAL PROSTHETIC MECHANICS. By D. M. SHAW. Demy 8vo. viii + 373 pages. 175 illustrations. 21s. net.

NURSING

MEDICAL NURSING. By A. S. WOODWARD, C.M.G., C.B.E., M.D., F.R.C.P. xii + 324 pages and 68 illustrations. 5s. net.

MEDICINE FOR NURSES. By J. C. HENDERSON, M.D., F.R.F.P.S. Crown 8vo. viii + 262 pages. 8s. 6d. net.

MIDWIFERY FOR NURSES. By H. RUSSELL ANDREWS, M.D., F.R.C.P. SIXTH EDITION. Crown 8vo. xii + 300 pages, with 77 illustrations. 6s. net.

SURGICAL NURSING AND THE PRINCIPLES OF SURGERY FOR NURSES. By RUSSELL HOWARD, C.B.E., M.S., F.R.C.S. FOURTH EDITION. Crown 8vo. xvi + 318 pages. Fully illustrated. 7s. 6d. net.

A PRACTICAL HANDBOOK OF SURGICAL AFTER-TREATMENT. By A. H. TODD, F.R.C.S. SECOND EDITION. xii + 236 pages. Illustrated. 5s. net.

LONDON: EDWARD ARNOLD & CO., 11 & 43 MADDOX ST., W.1.

